Extra-hepatic portal vein obstruction (EHPVO) with cholangiopathy: imaging based criteria on the basis of CT and MRCP findings for disease classification and management

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Purpose

Extrahepatic portal vein obstruction (EHPVO) is an uncommon clinical condition, seen in less than 1% patients presenting to specialized liver clinics. (1) The significance of this entity lies in its secondary manifestation in the form of portal cavernoma cholangiopathy or portal biliopathy. These changes in the extra and intra-hepatic bile duct system are a result of extrinsic and intrinsic changes in the bile duct wall caused by extensive peri-biliary collateral formation due to primary or secondary thrombosis of the portal vein. (2) The natural history of this disease has been found to be silent, insidious and progressive with a late clinical presentation in unsuspected patients. (3) Occasionally (in 5-40%), the disease presents with secondary complications such as cholangitis, biliary calculi or obstructive jaundice which require invasive therapeutic procedures such as endoscopic biliary stenting. (4) Radical management in the form of shunt surgery and splenectomy is required in patients presenting with hypersplenism, variceal bleed or portal hypertension to reduce the underlying primary increase in portal pressure. (5) The advent of mesenteric-left-portal bypass or Rex shunt with optional biliary bypass surgery has completely changed the current management paradigm of EHPVO with portal biliopathy in the pediatric age group and to a large extent in selective the adult population. (6) Different study groups have used array of clinical and laboratory markers as selection criteria to manage patients of EHPVO with biliopathy through surgical, endoscopic and conservative management. (7) There is a need for objective and uniform criteria to define the algorithm of management in these patients. The purpose of this study was to propose an imaging based predictability criteria for patients to be selected as potential candidates for surgery and guide the clinician towards disease progression and post operative follow up with the help of the radiologist.

The secondary objectives included:

a) Comparison of imaging parameters with biochemical liver function tests as significant predictors of disease complication and management strategization

b) To classify biliary strictures, duct contour, size and angulations on imaging according to the disease severity and proposed management

c) To assess patients in the post operative period on imaging in comparison with pre-operative findings and propose a criteria for adequate time interval and selective patient population for follow up
Methods and materials

A prospective study of 61 patients of EHPVO with portal cavernoma cholangiopathy or biliopathy using dynamic CT and MRCP was performed from August 2010-15 at a tertiary liver institute. The inclusion criterion consisted of patients with primary portal vein thrombosis with overlying features of portal biliopathy wherever applicable. Patients with other etiologies of portal vein thrombosis or biliopathy such as hepatic and pancreatic malignancies, chronic liver disease, sclerosing cholangitis and biliary calculi were excluded. Patients who underwent surgery versus conservative management were segregated into two groups.

Imaging Techniques:

**Dynamic triple phase MDCT** study was performed on a 64-row spectral CT scanner. Scan parameters included: 120 kV with automated mA, 0.6 s rotation time, speed 55 mm/rotation, pitch of 1.375:1, detector coverage of 40 mm, and matrix size of 512 x 512. Low osmolarity non-ionic contrast medium @1.5#2.0 ml/kg body weight with iodine concentration of 400 mg/ml was administered intravenously at a rate of 4 ml/ using bolus tracking software with reconstruction of slices @ 2.5 mm thickness.

**MRCP imaging** was performed on a 3 Tesla scanner using a phased array TORSOPA coil. Imaging protocol for sequences obtained was: (a) two-dimensional fast imaging employing steady state acquisition (2D FIESTA) sequences in axial and coronal planes with a slice thickness of 3 mm and at 0.5 mm intervals. (TR 4.7 ms, TE 2.1 ms, slab thickness 3 mm, FOV 35 cm, #ip angle 70°, and matrix 224 x 352 (b) Three-dimensional magnetic resonance cholangiopancreatography (3D MRCP) sequences were obtained (in axial and coronal planes) using respiration triggered heavily weighted T2 sequence FRFSE#XL) with contiguous thin sections (1.4 mm/0.7 overlap). (c) T2 SSFSE sequences (with breath hold) in thick slabs of 40 mm in coronal oblique planes at 20° increments, keeping the common bile duct as the center of rotation. Imaging parameters for SSFSE sequences included: Repetition time (TR) 2100 ms, time to echo (TE) 80.1 ms, slab thickness 0.5 mm, field of view (FOV) 38 cm, and matrix 288 x 192. (d) Unenhanced axial sequences with a slice thickness of 5 mm at 1 mm intervals, including T1W and T2W single shot fast spin echo (SSFSE) sequences with and without fat suppression.

Data analysis: Prospective study of both groups, for various imaging parameters was statistically analyzed for predictability of clinical severity warranting surgery as the preferred form of management: Various parameters studied were as follows:
EHPVO was defined as non-opacified main portal vein (in chronic thrombosis) or hypodense intravascular filling defect (in acute thrombosis), replaced or supplemented by multiple tortuous periportal enhancing venous collaterals (cavernoma) e.g. (Figure 1)

**Fig. 1:** Figure 1: Dynamic CT scan of the upper abdomen with reconstruction and post processed images depicting features of EHPVO 1a. Coronal Minimum intensity projection [MIP] showing the original portal vein replaced by a bunch of collaterals (white arrow) extending along the entire spleno-portal axis as seen in Figure 1b (yellow arrow). 1c: Axial section of contrast CT of the liver shows multiple collaterals replacing the intra-hepatic divisions (blue and yellow asterix) of portal vein. 1d: Axial section of liver at porta reveals portal cavernoma with mildly dilated bile duct surrounded by paracholedochal collaterals (white arrow)

**References:** Radiodiagnosis, Institute of Liver & Biliary Sciences, Institute of Liver & Biliary Sciences - New Delhi/IN Fig. 1 on page 20

Figure 1: Dynamic CT scan of the upper abdomen with reconstruction and post processed images depicting features of EHPVO
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· Liver morphology (left, caudate lobe or right lobe hypertrophy/atrophy of liver) e.g. (Figure2a) Fig. 23 on page

Fig. 2: Figure2: Dynamic CT scan of the upper abdomen showing liver and spleen morphology analysis in patient with primary EHPVO 2a: Caudate lobe hypertrophy (arrow) with changes in liver morphology such as widened periportal and interlobar fissure space (*)

References: Radiodiagnosis, Institute of Liver &Biliary Sciences, Institute of Liver &Biliary Sciences - New Delhi/IN
Spleen span and morphology (cranio-caudal span in coronal sections with longest measurement in cms) e.g. (Figure 2b)

Fig. 2b: Dynamic CT scan of the upper abdomen showing liver and spleen morphology analysis in patient with primary EHPVO 2b: Massive splenomegaly with cranio-caudal span (red arrow) as measured during course of study with caudal end extending to the left iliac fossa

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- Presence or absence of ascites
- Presence of splenic vein and/or superior mesenteric vein thrombosis e.g. (Figure 3)

Fig. 3: Contrast enhanced CT of the spleno portal axis in the portal venous phase in a patient with primary EHPVO 3a: Collateral formation along the course of thrombosed retropancreatic splenic vein (white arrow) 3b: Coronal section of the CT scan showing collateral formation in the location of thrombosed superior mesenteric vein (SMV) (bold black arrow)

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- Presence of paracholedochal (parallel to CBD) venous plexus e.g. (Figure 4)
Fig. 4: Coronal reconstruction of dynamic upper abdomen CT showing splenoportal axis collaterals 4a, b: Axial sections and coronal reconstruction of dynamic upper abdomen CT showing multiple tortuous collaterals in the paracholedochal location (bold yellow arrow) and along the gall bladder wall (bold black arrow)

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- Presence of epicholedochal (on the surface of CBD) venous plexus e.g. (Figure 5)

Fig. 5: Coronal reconstruction of dynamic upper abdomen CT showing different splenoportal axis collaterals 5a, b: axial sections of the dynamic upper abdomen CT scan showing epicholedochal collaterals (yellow bold arrow) with central duct (red outline) in the extra-hepatic location. 5c, d: axial sections of the dynamic upper abdomen CT scan showing epicholedochal collaterals (yellow bold arrow) with central duct (red linear outline) in the intra-hepatic location of the left and right ductal systems
Figure 5: Coronal reconstruction of dynamic upper abdomen CT showing different splenoportal axis collaterals

5a, b: axial sections of the dynamic upper abdomen CT scan showing epicholedochal collaterals (yellow bold arrow) with central duct (red outline) in the extra-hepatic location. 5c, d: axial sections of the dynamic upper abdomen CT scan showing epicholedochal collaterals (yellow bold arrow) with central duct (red linear outline) in the intra-hepatic location of the left and right ductal systems

- Gall bladder (GB) calculi e.g. (Figure 6a)

**Fig. 6:** Figure 6a: Axial non contrast CT in a 25 year old lady with EHPVO showing intraluminal gall bladder hyperdense calculus (bold yellow arrow) Figure 6b: coronal T2WI sequence acquired on a 3T MRI scanner of a 25 year old lady with EHPVO showing hypointense serpiginous flow voids of peri-cholecystic collaterals (bold black and white arrow) Figure 6c: coronal T2WI sequence acquired on a 3T MRI scanner of the 25 year old lady with EHPVO showing hypointense serpiginous flow voids of paracholedochal collaterals causing smooth extrinsic impression on the duct wall (yellow bold arrows)

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Figure 6c: coronal T2WI sequence acquired on a 3T MRI scanner of the 25 year old lady with EHPVO showing hypointense serpiginous flow voids of paracholedochal collaterals causing smooth extrinsic impression on the duct wall (yellow bold arrows)

· Gall bladder varices along the wall (Figure 4a, 6b-c) Fig. 6 on page 23

· Porto-systemic collaterals (divided as per location into groups of perigastric, paraesophageal, perisplenic, mesenteric, peri-rectal, peripancreatic) e.g. (Figure 7) Fig. 7 on page 24

**Fig. 7:** Figure 7: Dynamic CT scan of a patient (in portal venous phase) with EHPVO demonstrating various types of portosystemic collaterals 7a: Coronal MIP reconstruction of dynamic CT scan in a 30 year old male patient with EHPVO showing gastro-esophageal shunt pathway (yellow bold arrow). 7b: Axial dynamic CT scan showing thrombosed spleno-portal axis (bold white arrow) with areas of calcification in the portal vein wall in the above patient; consistent with diagnosis of EHPVO. 7c: Axial sections of the CT scan in the patient with EHPVO showing paraesophageal collaterals (bold black arrow) and perigastric collaterals (bold yellow arrow)

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· Analysis of intra and extrahepatic biliary system (with regard to biliary caliber, dilatation, intraductal calculi) e.g. (Figure 8) Fig. 8 on page 24

![Fig. 8: Figure8: 2D and 3D MRCP projections for analysis of the bile duct dilatation, contours and calculi 8a: 2D MRCP sequence in a 32 year old male patient with EHPVO showing extrahepatic bile duct normal caliber with wavy contour (bold yellow arrow). Figure8b, c: Axial 3D MRCP sequence showing mildly prominent intrahepatic bile ducts (bold) in the above patient with EHPVO and symptomatic biliopathy (bold white arrow) Figure8d. 2 D MRCP projection in a 26 year old female patient with EHPVO showing intraductal filling defects (calculi) in the extra and intrahepatic segments

References: Radiodiagnosis, Institute of Liver &Biliary Sciences, Institute of Liver &Biliary Sciences - New Delhi/IN

Figure8: 2D and 3D MRCP projections for analysis of the bile duct dilatation, contours and calculi

8a: 2D MRCP sequence in a 32 year old male patient with EHPVO showing extrahepatic bile duct normal caliber with wavy contour (bold yellow arrow). Figure8b, c: Axial 3D MRCP sequence showing mildly prominent intrahepatic bile ducts (bold) in the above patient with EHPVO and symptomatic biliopathy (bold white arrow) Figure8d. 2 D MRCP
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· CT, MRI and MRCP images were used to identify CBD contour which was further categorized as:

i. Smooth: defined as no visible contour abnormality e.g. (Figure 9a, b)

![Figure 9a and 9b](image)

**Fig. 21**: Figure 9: 2D and 3D MRCP projections for analysis and categorization of the bile duct contour 9a: 2D MRCP sequence shows no significant or visible contour abnormality of the extrahepatic bile duct (outlined white arrow in Figure 9a) in a patient with EHPVO and visible portal biliopathy and intrahepatic bile duct dilatation (bold white arrow in Figure 9b).

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Figure 9: 2D and 3D MRCP projections for analysis and categorization of the bile duct contour

9a: 2D MRCP sequence shows no significant or visible contour abnormality of the extrahepatic bile duct (outlined white arrow in Figure 9a) in a patient with EHPVO and visible portal biliopathy and intrahepatic bile duct dilatation (bold white arrow in Figure 9b).

ii. Irregular: defined as: nodular, thumb-like or shallow impressions along the duct wall e.g. (Figure 9c)
Fig. 9: Coronal FIESTA, T1WI sequence acquired on a 3T MRI scanner of a 25 year old lady with EHPVO showing mildly hypointense epicholedochal collaterals along the surface of the CBD causing irregular, thumb printing like contour (red outlines) of the duct wall (bold yellow arrows)

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Figure 9c: Coronal FIESTA, T1WI sequence acquired on a 3T MRI scanner of a 25 year old lady with EHPVO showing mildly hypointense epicholedochal collaterals along the surface of the CBD causing irregular, thumb printing like contour (red outlines) of the duct wall (bold yellow arrows)
iii. Bile duct stricture formation: further graded into (according to upstream dilatation):

a) Mild (Grade 1) e.g. (Figure 10a, b) Fig. 10 on page 26

**Fig. 10:** Figure 10: 2D and 3D MRCP projections for analysis and categorization of the bile duct stricture grading Figure 10a: 2D MRCP projection of an 11 year old child showing smooth stricture of the lower end of the CBD (bold white arrow) with mild upstream biliary prominence. Figure 10b: Contrast enhanced coronal sections of T1WI of the dynamic MR examination of the same patient shows multiple collaterals (C) along the comm. on hepatic duct (D) with narrowing of the duct beyond the middle segment (bold yellow arrow). Figure 10c: 3D MRCP projection of a 28 year old male patient with mid CBD stricture (bold orange line with yellow arrow) showing moderate upstream biliary dilatation (bold white arrow) Figure 10d: 3D MRCP projection of a 21 year old female patient with distal third CBD stricture (bold red arc with yellow arrow) showing severe upstream biliary dilatation (bold white arrow)

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b) Moderate (Grade 2) e.g. (Figure 10c)

Fig. 24
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Figure 10c: 3D MRCP projection of a 28 year old male patient with mid CBD stricture (bold orange line with yellow arrow) showing moderate upstream biliary dilatation (bold white arrow)
c) Severe (Grade3) as per upstream dilatation e.g. (Figure 10d)

**Figure 10d:** 3D MRCP projection of a 21 year old female patient with distal third CBD stricture (bold red arc with yellow arrow) showing severe upstream biliary dilatation (bold white arrow)

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Figure 10d: 3D MRCP projection of a 21 year old female patient with distal third CBD stricture (bold red arc with yellow arrow) showing severe upstream biliary dilatation (bold white arrow)
· Pre stenotic dilatation (present or absent)

· Common bile duct angle: Bile duct angle was measured in each patient by measuring the intersection of lines drawn along the long axis of common bile duct. Angle > 145° was taken to be normal (Figure 11a) Fig. 11 on page 27

Fig. 11: Figure 11a: 3D MRCP projection in a 21-year-old male patient with CBD angulation along its own axis of > 145° (red arc depicting an obtuse angle more than 145°) considered normal Figure 11b: 3D MRCP projection in a 32-year-old male patient with CBD angulations along its own axis of < 145° (red arc depicting a relatively acute angle less than 145°) considered abnormal

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with narrowing of the duct beyond the middle segment (bold yellow arrow).

while values lower than 145° (Figure 11b) was considered greater angulations' (tabulated as: less or more than angle of 145 degrees)

Total bilirubin, Serum alkaline phosphate (SAP) and gamma glutamyl transferase (GGT) were also recorded to assess predictability criteria for surgical management.

Post operative imaging was analyzed with respect to:
· Median follow up time

· Median time for regression of collaterals and CBD angle to normal range

· Shunt patency (Figure 12) Fig. 12 on page 28

![Fig. 12: Dynamic upper abdomen axial CT showing patent spleno-renal shunt](image)

**Fig. 12**: Figure 12: Dynamic upper abdomen axial CT showing patent spleno-renal shunt 12a, b, c: Contrast enhanced shunt showing opacification suggesting patency with surgical hyperdense surgical clips (bold arrow) and connectivity between retropancreatic splenic vein and left renal vein at two ends (arrow)

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Figure 12: Dynamic upper abdomen axial CT showing patent spleno-renal shunt

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**Statistical analysis:**

Categorical data was described as frequency and proportion. Continuous data was presented as mean with standard deviation or median with interquartile range. The comparison of proportion in two groups was done by Chi square test or Fisher exact test, as required. The comparison of mean was done by student T test or Mann Whitney U Test as required.
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Results

A total of 61 patients (mean age 23.5±10.7 years, 22 males and 39 females) were prospectively enrolled in the study over a period of 5 years at our tertiary liver hospital.

Bilobar IHBR dilatation was seen in 98% with CBD abnormality in 100% patients. Extrinsic ductal impressions were present in 47/61 (77 %), stricture in 16% and smooth contour in 6% were observed. All strictures were < 10mm in length. CBD angle showed a mean of 143° ± 15.5° (range 95° - 165°) with 60% patients showing ≥ 145° angle. Isolated cholelithiasis versus choledocholithiasis was present in 50% versus 8%. Concurrent calculi were seen in 10% patients. Altered liver and spleen morphology was seen in 64 and 96 % patients respectively with, splenic artery aneurysms in 14% and gamma-gandy bodies in 20%. Splenic and SMV thrombosis was seen in 34 and 44 % respectively. Epicholedochal, gall bladder, paracholedochal collaterals were present in 17, 78, 100 % patients. Systemic collaterals were observed in 100% patients, paraesophageal in 71% and pararectal varices in 46% patients respectively. Presence of splenic vein, superior mesenteric vein thrombosis, epicholedochal and paracholedochal venous plexus, porto-systemic collaterals (all groups), gall bladder varices, liver morphology in the form of segmental hypertrophy or atrophy did not provide significant statistical evidence to suggest a definite role in decision making of the appropriate management.

22 underwent splenectomy and surgery in the form of proximal lienorenal shunt. Mean age in the operated group was found to be older (p>0.05) than the non-operated group (26.9±8.4 Vs 21.6±11.5 years) which is likely due to disease progression. The number of males to be operated was significantly higher (54.5% males Vs 25.6% females) (p=0.02) suggesting faster disease progression and unfavorable prognosis in males compared to females. Mean CBD caliber in the operated group was almost twice that of the non-operated group (8.3±2.3 Vs 4.6±1.5 mm) (p=0.001) suggesting the role of portal biliopathy in strategizing surgical approach. (Figure13, 14) Fig. 13 on page 39.
Fig. 13: Figure 13: Comparative 3D MRCP projections of two patients for assessment of the CBD caliber and intraductal calculi Figure 13a: 3D MRCP projections of a 32 year old male patient with portal biliopathy showing dilated CBD (yellow arrow) with intraductal calculi (seen as filling defects) Figure 13b: 3D MRCP projections of the 32 year old male patient with portal biliopathy showing gross reduction in the CBD caliber (yellow arrow) and intraductal linear thin endoluminal stent (green arrow) post operatively and after intraductal stent placement Figure 13c: 3D MRCP projections of a 46 year old male patient with portal biliopathy showing mildly dilated irregular contoured CBD (yellow arrow) without intraductal filling defects or calculi. Patient was treated with medical management

References: Radiodiagnosis, Institute of Liver & Biliary Sciences, Institute of Liver & Biliary Sciences - New Delhi/IN

Figure 13: Comparative 3D MRCP projections of two patients for assessment of the CBD caliber and intraductal calculi

Figure 13a: 3D MRCP projections of a 32 year old male patient with portal biliopathy showing dilated CBD (yellow arrow) with intraductal calculi (seen as filling defects)

Figure 13b: 3D MRCP projections of the 32 year old male patient with portal biliopathy showing gross reduction in the CBD caliber (yellow arrow) and intraductal linear thin endoluminal stent (green arrow) post operatively and after intraductal stent placement

Figure 13c: 3D MRCP projections of a 46 year old male patient with portal biliopathy showing mildly dilated irregular contoured CBD (yellow arrow) without intraductal filling defects or calculi. Patient was treated with medical management

Fig. 14 on page 39
Fig. 14: Box plot representation of the statistical analysis of the CBD size in operated versus non-operated groups, where CBD size was found to be significantly higher in operated patients as compared to the non-operated patients.

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IHBRD was found in all patients regardless of the management, since it is more of a disease characteristic. Choledocholithiasis was significantly higher in the operated patient set (83.3% vs 24.5%) (p=0.001) suggesting that the presence of CBD calculi is a significant predictor for a complicated clinical spectrum which would lead to surgery more often than medical management. (Figure 13, 15)
Fig. 15: Figure15: Bar diagram representation of the statistical analysis of the extent of prestenotic dilatation, choledocholithiasis and cholelithiasis in operated versus non operated groups, where presence of all three were found to have found to be significant (p<0.05) in the operated group

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Figure15: Bar diagram representation of the statistical analysis of the extent of prestenotic dilatation, choledocholithiasis and cholelithiasis in operated versus non operated groups, where presence of all three were found to have found to be significant (p<0.05) in the operated group

Presence of gallstones (57% Vs 25%) also showed significant (p=0.03) predictability for surgical management. Amongst the operated group, increasing severity of CBD stricture from Grade 1 to grade 3 showed a rising predilection for surgery (22.9%, 47.1%, 66.7% respectively) with p=0.027 showing statistical significance. (Figure16) Fig. 16 on page 41
Fig. 16: Bar diagram showing, increasing severity of CBD stricture from Grade 1 to grade 3 with comparably rising predilection for surgery (22.9%, 47.1%, 66.7% respectively) (p=0.027).

References: Radiodiagnosis, Institute of Liver & Biliary Sciences, Institute of Liver & Biliary Sciences - New Delhi/IN

Figure 16: Bar diagram showing, increasing severity of CBD stricture from Grade 1 to grade 3 with comparably rising predilection for surgery (22.9%, 47.1%, 66.7% respectively) (p=0.027).

Presence of obvious pre-stenotic dilatation (72.7% Vs 28%) was likely more relevant for clinical management purpose than the stricture itself. (Figure17) Fig. 17 on page 42
Fig. 17: Figure 17: Comparative 3D MRCP sections of two patients with severe (grade 3) stricture of the CBD for decision making in terms of surgical or conservative management

Figure 17a: 3D MRCP coronal projections of a 21 year old lady who underwent surgical management on the basis of prestenotic (bold white arrow) upstream biliary dilatation (bold yellow arrow) which is significantly higher compared to patient in Figure 17b

Figure 17b: 3D MRCP coronal projections of a 16 year old girl who was managed conservatively despite the grade 3 severe stricture on the basis of comparatively lower prestenotic (bold white arrow) upstream biliary dilatation (bold yellow arrow) compared to patient in Figure 17a

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Figure 17: Comparative 3D MRCP sections of two patients with severe (grade 3) stricture of the CBD for decision making in terms of surgical or conservative management
Figure 17a: 3D MRCP coronal projections of a 21 year old lady who underwent surgical management on the basis of prestenotic (bold white arrow) upstream biliary dilatation (bold yellow arrow) which is significantly higher compared to patient in Figure 17b.

Figure 17b: 3D MRCP coronal projections of a 16 year old girl who was managed conservatively despite the grade 3 severe stricture on the basis of comparatively lower prestenotic (bold white arrow) upstream biliary dilatation (bold yellow arrow) compared to patient in Figure 17a.

Spleen size (21.2±3.9 Vs 17.9±4.1 cms) was found larger in the operated group (p=0.004). (Figure 18)

**Fig. 18**: Figure 18: Box plot representation of the statistical analysis of the spleen size in operated versus non-operated groups, where larger spleen size was found to be significantly higher in operated patients as compared to the non-operated patients.

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Figure 18: Box plot representation of the statistical analysis of the spleen size in operated versus non operated groups, where larger spleen size was found to be significantly higher in operated patients as compared to the non operated patients.

The mean value of the CBD angle in the operated group versus non operated group was found to be lower (139.7° ±9.1° Vs 142.7° ±16.5° SD) with p=0.36. (Figure 19) Fig. 19 on page 44

**Fig. 19:** Figure 19: Box plot representation of the statistical analysis of the CBD angle size in operated versus non operated groups, where smaller mean CBD angle was observed in operated patients as compared to the non operated patients.

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Irregular duct contour (38.6 % Vs 0%) showed higher predilection in the operated group but was not found statistically significant (p > 0.05).

Laboratory parameters (Total bilirubin, SAP and GGT) showed median values of 1.4(IQR 1.1-1.8)mg/dl versus 1.6(IQR 0.9-2.4) mg/dl in non operated, 93(IQR 77-127) versus 99(IQR 61-167) IU and 43 (IQR 12.7-68) versus 16(IQR 12-34) IU respectively in operated versus non operated groups. These did not show significant change in both groups, suggesting paucity of evidence to back their role in clinical decision making and therapeutic management.

22 patients underwent splenectomy with proximal lienorenal shunt surgery followed by dynamic CT at 3-6 months intervals. Median post operative imaging follow up was performed at 3 (IQR 3-10) months. Shunt thrombosis was seen in 6/22 operated patients at 12 months. Median time for regression of collaterals and portal biliopathy was 3 (IQR 3-22) months. Shunt patency was found in 72.7% patients who showed regression of collateral circulation whereas no significant change was noted in the patients with thrombosed shunt. Long term follow up at 1 year showed significant changes in collateral circulation whereas no change in imaging findings was present at 6-12 months. (Figure 20) Fig. 20 on page 45

**Fig. 20:** Contrast enhanced dynamic CT in PVP for comparison of pre and post operative extent of collaterals in the abdomen

**Figure 20a:** Contrast enhanced dynamic CT in PVP in the pre-operative period showing multiple collaterals at the porta (yellow arrow) and in the mesentery (white arrow)

**Figure 20b:** Contrast enhanced dynamic CT in PVP in the post-operative period after 1 year in the same patient on follow up showing significant reduction in the extent of collaterals in the region of porta (yellow arrow) and the mesentery (white arrow)

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Figure20: Contrast enhanced dynamic CT in PVP for comparison of pre and post operative extent of collaterals in the abdomen
Figure 20a: Contrast enhanced dynamic CT in PVP in the pre-operative period showing multiple collaterals at the porta (yellow arrow) and in the mesentery (white arrow).

Figure 20b: Contrast enhanced dynamic CT in PVP in the post-operative period after 1 year in the same patient on follow up showing significant reduction in the extent of collaterals in the region of porta (yellow arrow) and the mesentery (white arrow).

Our study revealed that an imaging based criteria with the following predictors, namely (CBD caliber, Grade of CBD stricture, prestenotic dilatation, cholelithiasis, spleen span and male gender) could help categorize patients into medical or surgical management groups. We also propose a mean follow up time of at least 1 year for repeat imaging to assess the condition of the patient, regression of collaterals and portal biliopathy features, especially in cases where surgery is the choice of treatment and adequate shunt patency is visualized on ultrasound during follow up visits, so as to decrease the frequency of scanning in this set of patients.
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**Fig. 19:** Box plot representation of the statistical analysis of the CBD angle size in operated versus non-operated groups, where a smaller mean CBD angle was observed in operated patients as compared to the non-operated patients.

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Conclusion

We propose an imaging and evidence based criteria for EHPVO with cholangiopathy based on specific predictors such as bile duct caliber, severity of stricture, prestenotic dilatation, cholelithiasis and spleen size for classifying these patients into subgroups who may benefit from surgical management instead of conservative medical management.
References


