

A Decade of Endovascular Management in Budd–Chiari Syndrome: A Single-Centre Retrospective Review and Clinical Outcomes

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Research Article

Keywords:

Posted Date: September 29th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10974959/v1>

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Additional Declarations: No competing interests reported.

Abstract

Objective

Retrospective review to assess the technical success and long term clinical outcome of various endovascular interventions in treatment of Budd Chiari syndrome (BCS) in the Indian adult population at a single tertiary care centre.

Materials and Methods

93 patients with BCS who underwent endovascular intervention at a single tertiary care centre from January 2013 to March 2025 were retrospectively included. Patient records were examined for demographic characteristics, clinical data, venous involvement pattern on imaging, type of interventional radiology procedure conducted, operator involvement (n = 1 primary operator) and clinical outcomes.

Results

Mean age of study population was 29.5 years (n = 93 patients), with 43 being male and 50 females. Isolated inferior vena cava obstruction (35.5%) was the predominant pattern of involvement. Mean duration of follow up after the procedure was 32.1 months. Technical success rate was 100%. Cumulative clinical success 1 year, 3 year and 5 year was 84.5%, 79.7%, and 76.9% respectively. 4 deaths were noted, including 1 procedure related death. 12 of 93 patients required reintervention. The patency rate following endovascular intervention at 1 year, 3 year, and 5 year was 85.4%, 80.6%, and 77.8% respectively. The 5 year survival rate was 95.6%. No clinically significant difference was seen between recanalization and TIPS/DIPS (transjugular / direct intrahepatic portosystemic shunt) group for both patency rate, and 5 year survival.

Conclusion

Endovascular intervention is safe and effective in management of BCS with high technical success, clinical success, and patency rates.

INTRODUCTION

Budd-Chiari syndrome (BCS) is a rare disorder that affects approximately one in every 100,000 individuals worldwide and is more common in the Asian population (1, 2). BCS results from obstruction of the hepatic venous outflow tract, either at the level of the main hepatic veins (hepatic veins) or the suprahepatic segment of the inferior vena cava (IVC). Primary BCS is characterized by thrombosis, stenosis, or membranous obstruction of the hepatic veins or IVC, whereas secondary BCS occurs due to external compression or invasion by entities such as tumor, cyst, or abscess (2, 3). Membranous web-like occlusion is considerably more common in Asian populations than in Western cohorts, and patients frequently present with a gradually progressive rather than acute or fulminant clinical course (4, 5, 6). Management of BCS typically follows a step-wise escalation that includes anticoagulation, endovascular recanalization procedures, transjugular or direct intrahepatic portosystemic shunt (TIPS / DIPS) creation when venous recanalization is not feasible, and liver transplantation in advanced or refractory cases (4, 7).

The aim of the present study is to assess the technical success rate, clinical response, and reintervention rates following various endovascular procedures for the management of BCS in our patient population.

MATERIALS AND METHODS

Approval of the institute ethical board was obtained for the retrospective observational study. Informed consent for retrospective data analysis was waived by the Institutional Ethics Committee, as the study involved review of existing anonymized medical records and imaging data. In our study, patients with chronic BCS who underwent percutaneous endovascular management between January 2013 and March 2025, were included (121 patients). Chronic BCS was defined as clinical and/or imaging findings of venous outflow obstruction persisting for more than 6 weeks, often accompanied by features such as caudate lobe hypertrophy, intrahepatic collateral veins, heterogeneous hepatic enhancement, or signs of portal hypertension. Patients < 14 years of age (n = 9), patients with inherited thrombophilia (n = 1), secondary BCS (n = 2) and non-consenting patients (n = 7) were excluded from the study. Patients were included irrespective of age (above 14 years) or gender, contingent upon the availability of sufficient clinical and procedural documentation. Initially, 102 patients meeting inclusion and exclusion criteria were included in the study, out of which 9 patients were excluded in view of incomplete clinical, imaging or procedural data in the hospital information system (Fig. 1). All data were anonymized and managed in accordance with institutional ethical standards.

Patient records were examined for demographic characteristics (age, gender), clinical and laboratory data, venous involvement pattern on imaging (isolated IVC involvement, isolated hepatic veins involvement, combined IVC and hepatic veins involvement, short segment <3cm, long segment >3cm), type of interventional radiology procedure conducted (angioplasty, stenting, TIPS, or DIPS), and clinical outcomes (clinical success, clinical failure, re-intervention, and mortality). The diagnosis of BCS was made using standard criteria based on clinical or laboratory features of hepatic dysfunction and imaging features of hepatic venous outflow tract obstruction. The age of onset was defined as the age at which symptoms first appeared, as reported by the patient or close relatives. Child-Pugh and MELD scores were not used as primary determinants of treatment allocation. In chronic BCS, hepatic dysfunction is frequently secondary to venous outflow obstruction and may improve following recanalization. Therefore, procedural decision-making was primarily based on anatomical feasibility of recanalization and degree of venous involvement on imaging. However, liver function parameters required to derive Child-Pugh and MELD scores (bilirubin, INR, albumin, presence of ascites, and encephalopathy) were available in the retrospective record review and were documented. BCS

was categorized into three categories based on the type of venous occlusion in the pre-procedural imaging, namely, Type I – isolated IVC obstruction; Type IIa – isolated short-segment hepatic veins obstruction (where at least one hepatic vein shows short-segment obstruction of ≤ 3 cm in length); Type IIb – isolated long-segment hepatic veins occlusion (where all hepatic veins show long-segment occlusion of > 3 cm in length); and Type III – combined involvement of the IVC and hepatic veins. Interventional radiology procedures were tailored to the type of venous involvement.

At our institute, BCS is managed using a step-wise approach (Fig. 2). Whenever feasible, combined endovascular recanalization procedures and systemic anticoagulation are used as the first line of treatment. Recanalization restores physiological hepatic venous outflow and is associated with lower incidence of hepatic encephalopathy. In patients who do not respond to recanalization procedures or in whom recanalization is not suitable (multiple long segment hepatic veins occlusion, cirrhotic liver, etc.), transjugular / direct intrahepatic portosystemic shunt (TIPS / DIPS) or liver transplantation is considered. Endovascular procedures for recanalization and TIPS / DIPS creation are preferred over surgical shunt creation due to their minimally invasive nature, lower blood loss, lower infection rate, lower morbidity, shorter hospital stay, and better long-term survival (4, 7). IVC recanalization by angioplasty alone or with stent placement is often sufficient to treat isolated IVC obstruction. Short segment hepatic veins occlusions are treated with angioplasty with or without stenting, whereas multiple long segment hepatic veins occlusions (> 3 cm) usually required TIPS / DIPS creation.

All individuals with confirmed BCS who underwent percutaneous endovascular interventional procedure and post procedure follow up at 1 month or higher during study period were eligible for analysis. Patients who died immediate post procedure and within 1 month were also included within the study for analysis.

Percutaneous Endovascular Procedures

Based on the preprocedural evaluation, imaging and clinical findings, patients who gave their consent for endovascular therapy underwent recanalization procedures for hepatic veins and/or IVC or TIPS/DIPS. All patients received anticoagulant medication after the intervention in order to keep their INRs between 2 and 3. The interventional procedures that were conducted are outlined below.

IVC recanalization - In patients with IVC obstruction, femoral access was preferred over jugular access. After passing a guidewire through the occluded segment, a balloon catheter was used to perform serial dilatation (Fig. 3). If there was less than 50% residual stenosis and a pressure gradient less than 3 mmHg, technical success was deemed achieved. Patients who had persistent IVC stenosis following angioplasty (residual stenosis of more than 50% or pressure gradients of more than 3 mmHg) were stented.

Hepatic vein recanalization - In patients with short segment occlusion of hepatic veins, isolated hepatic veins recanalization was attempted. The optimal hepatic veins (straight, echo-free lumen, and with a good calibre of roughly 7–8 mm) was chosen for intervention. All procedures were performed through the right trans jugular route. In patients in whom the hepatic vein could not be cannulated via the right transjugular route, percutaneous transhepatic access procedure was done, where access into a peripheral hepatic vein branch was obtained using ultrasound and fluoroscopic guidance with a fine needle. A hydrophilic guidewire was then advanced across the occluded segment into the IVC and snared from the transjugular sheath to establish a through and through tract, over which balloon angioplasty and/or stenting were subsequently performed from the transjugular end.

Balloon dilatation was most commonly performed using a 10 mm $\times$ 4 cm balloon catheter (Armada, Abbott Vascular), selected to approximate the native hepatic vein diameter and lesion length. For hepatic vein recanalization, self-expanding uncovered bare metal stents (nominal diameter 10 mm) were used in cases with persistent significant residual stenosis after angioplasty.

Technical success was considered if there was $< 50\%$ residual stenosis and pressure gradient across the stenosis decreased below 3mmHg. Patients with persistent hepatic stenosis after angioplasty ($> 50\%$ stenosis or pressure gradients of > 3 mmHg), underwent stenting (Fig. 4). The standard procedure for patients with a combined block of both IVC and hepatic veins was IVC angioplasty first, followed by hepatic veins angioplasty/stenting as previously mentioned.

DIPS / TIPS creation - DIPS/TIPS was performed on a subset of patients who had long segment occlusion of all three hepatic veins. DIPS and TIPS was created between IVC and portal vein either puncturing through the wall of IVC or through the existing stenosed hepatic veins ostium respectively (Fig. 5). Dedicated PTFE covered TIPS stents (e.g., VIATORR) were not available during the study period. Therefore, TIPS/DIPS tracts were created using an overlapping stent, with a proximal covered stent spanning the intrahepatic parenchymal tract and a distal overlapping uncovered bare metal stent in the portal vein / hepatic segment. Final tract and stent dilatation was performed using a 10 mm $\times$ 4 cm balloon (Armada, Abbott Vascular). Technical success for TIPS/DIPS was defined as decrease in portosystemic pressure gradient measured between mean portal vein pressure and mean right atrium pressure below 12 mmHg or $> 50\%$ reduction compared to preprocedural level.

Primary clinical success was defined using a composite clinical and laboratory response assessed at 1 month (± 14 days) post-procedure. Clinical improvement was considered present if any one of the following was documented: (i) reduction in ascites by ≥ 1 grade on clinical examination or ultrasound, or becoming paracentesis-free compared to baseline; (ii) reduction of peripheral edema by ≥ 1 grade; (iii) absence of any new episode of variceal upper gastrointestinal bleeding following the procedure; or (iv) improvement in hepatic encephalopathy by ≥ 1 West-Haven grade when applicable. Laboratory improvement was defined as any one of the following changes compared with baseline values: (i) decrease in total bilirubin by $\geq 25\%$ or to ≤ 2.0 mg/dL if previously elevated; (ii) increase in serum albumin by ≥ 0.3 g/dL if previously low; (iii) reduction in INR by ≥ 0.3 or normalization to ≤ 1.5 ; (iv) decrease in AST or ALT by $\geq 30\%$ if elevated. Primary clinical failure was defined as absence of improvement in both clinical and laboratory parameters at 1 month assessment or clinical deterioration (new or worsening ascites, variceal bleeding, or encephalopathy). Early deaths within 1 month of procedure, either due to liver failure, or procedure related complication, were also included in primary clinical failure. Recurrence was defined as initial improvement at 1 month followed by subsequent return of symptoms or worsening of laboratory parameters requiring re-intervention. 1 year, 3 year, and 5 year long term clinical success, and TIPS / DIPS patency rate, and 5 year survival rate was calculated using Kaplan Meier analysis.

Follow up

All the patients who underwent percutaneous intervention were followed up at 24 hours after the procedure, and at 1st, 3rd, 6th and 12th month, after the procedure and then every year. During each follow up the patients were evaluated clinically and radiologically to assess the response to the procedure. Radiological evaluation was done using ultrasonography and doppler assessment. Any suspicion of restenosis on imaging was evaluated with a conventional venogram, and stenosis, if present, was treated with angioplasty +/- stenting.

Clinical follow-up at 1 month was available for all 93 patients (100%), including 4 reported death within 30 days. Long-term follow-up data beyond 1 month was available in 88 patients (94.6%). Five patients were lost to follow-up after the first month, and their last documented clinical status was included in the survival analysis using an intention-to-follow approach.

Statistical analysis

Statistical analysis was done using IBM SPSS version 23. Descriptive statistics were used to summarize demographic, anatomical, and procedural characteristics. Categorical variables were compared using Chi-square test and continuous variables using Student's t-test or Mann–Whitney U test as appropriate. Survival and patency rates were estimated using Kaplan–Meier analysis, and statistical significance was tested using log rank test. Clinical follow-up at 1 month was available for all patients (100%). Long-term follow-up beyond 1 month was available in 88 out of 93 patients (94.6%). Due to the limited number of mortality events ($n = 4$) and recurrence events ($n = 9$), multivariate regression analysis to identify predictors of recurrence or mortality could not be reliably performed, and recurrence patterns were assessed descriptively.

RESULTS

The study comprised 93 patients with a mean age of approximately 29.5 years and standard deviation (SD) of 11 years (range – 14 to 65 years). 43 patients were male (46.2%) and 50 females (53.8%). The sex ratio was well balanced, and the difference was not statistically significant (p -value : 0.47). The demographic pattern according to type of hepatic veins and IVC involvement is presented in Table 1.

Table 1
Demography of patients according to type of IVC and HV involvement.

Pattern of IVC and HV involvement	Cases (n)	Cases (%)	Mean age (SD) in years	P-values* (age)	Sex ratio (Male : Female)	P-values* (sex ratio)
Isolated IVC involvement (Type 1)	33	35.5	26.7 (10.1)	0.14	16 : 17	0.80
Isolated short segment HV involvement (Type 2a)	26	28	28.8 (8.6)	0.75	14 : 12	0.44
Isolated long segment HV involvement (Type 2b)	27	29	34.4 (13.4)	0.02	10 : 17	0.34
Combined IVC and HV involvement	7	7.5	27 (7.2)	0.55	3 : 4	0.86

* P-values (for statistical comparisons with entire study population) : One sample Z-test for age; One sample Chi-square test for sex ratio.

In a cohort of 93 patients, isolated IVC involvement was the predominant anatomical pattern identified ($n = 33$, 35.5%). Isolated long segment hepatic veins involvement was seen in older age groups (mean – 34.4years, SD – 13.4years) compared to the entire study population (mean – 29.5 years, SD – 11 years), and the difference was statistically significant ($p = 0.02$). No statistically significant difference was observed between age of patients with other patterns of involvement and the entire study population. Also, no statistically significant difference was seen for sex ratio of all the patterns of involvement, when compared to the entire study population, and among themselves (P -value : 0.65, Chi-square test).

Liver function scores were retrospectively calculated from available laboratory and clinical parameters. Most patients had preserved hepatic function at presentation. The median Child-Pugh score was 6 (range: 5–9). No patients met criteria for Child-Pugh C at the time of intervention. The median MELD score was 9.9 (range: 7.6–19.2). These findings are consistent with chronic venous outflow obstruction with predominantly compensated liver function rather than intrinsic hepatic failure.

The primary interventions corresponded to the anatomical pattern of IVC and hepatic veins involvement. IVC angioplasty for IVC involvement was the most common procedure performed ($n = 32 / 93$). Mean duration of follow up after the procedure was 32.1 months (SD – 30 months), and range was 1 month to 118months.

Table 2 summarizes interventional radiological procedures performed in patients with various patterns of IVC and hepatic veins involvement, associated technical success rate, clinical outcome, and reinterventions performed.

Table 2
Interventional procedures performed in various patterns of IVC and HV obstruction.

Pattern of IVC and HV involvement	Type 1 (n = 33)		Type 2a (n = 26)		Type 2b (n = 27)	Type 3 (n = 7)		
Interventional procedure performed	IVC angioplasty (n = 32/33)	IVC stenting (n = 1/33)	HV angioplasty (n = 16/26)	HV stenting (n = 10/26)	TIPS / DIPS (n = 27/27) (4/27 patients had early liver cirrhosis morphology on imaging)	IVC + HV angioplasty (n = 5/7)	IVC angioplasty + HV stenting (n = 1/7)	IVC angioplasty + TIPS / DIPS (n = 1/7) (Patient features liver cirrhosis on imaging)
Technical success rate	32/32 (100%)	1/1 (100%)	16/16 (100%)	10/10 (100%)	27/27 (100%)	5/5 (100%)	1/1 (100%)	1/1 (100%)
Clinical outcome	1. Primary clinical failure – 3/32 (9.4%) (including 1 patient with persistent refractory ascites and patent IVC; 1 death secondary to liver failure; 1 death due to immediate post procedure hemopericardium) 2. Primary clinical success at 1 month – 29/32 (90.6%) (2/29 (6.9%) had recurrence after 1 month due to restenosis) 3. Other complications – 0	1. Primary clinical failure – 0/1 (0%) 2. Primary clinical success at 1 month – 1/1 (100%) (Recurrence after 1 month – 0/1 (0%)) 3. Other complications – 0	1. Primary clinical failure – 3/16 (18.7%) (including 2 restenosis; 1 death secondary to liver failure) 2. Primary clinical success at 1 month – 13/16 (81.3%) (1/13 had recurrence after 1 month due to restenosis) 3. Other complications – 0	1. Primary clinical failure – 0/10 (0%) 2. Primary clinical success at 1 month – 10/10 (100%) (1/10 (10%) had recurrence after 1 month due to instant thrombosis) 3. Other complications – 0	1. Primary clinical failure – 0/27 (0%) 2. Primary clinical success at 1 month – 27/27 (100%) (4/27 (14.9%) had recurrence after 1 month due to instant thrombosis) 3. Other complications – 1 (Hepatic artery injury)	1. Primary clinical failure – 1/5 (20%) (restenosis) 2. Primary clinical success at 1 month – 4/5 (80%) (1/4 (25%) had recurrence after 1 month due to restenosis) 3. Other complications – 0	1. Primary clinical failure – 0/1 (0%) 2. Primary clinical success at 1 month – 1/1 (100%) (Recurrence after 1 month – 0/1 (0%)) 3. Other complications – 0	1. Primary clinical failure – 1/1 (100%) (death secondary to liver dysfunction) 2. Primary clinical success at 1 month – 0/1 (0%) 3. Other complications – 0
Reinterventions performed	2 (1 patient with recurrence underwent IVC angioplasty at 10 months post primary intervention, and 1 patient underwent IVC stenting at 9 months)	–	3 (2 patient with clinical failure underwent HV angioplasty at 4th month post primary intervention and stenting at 3 months respectively; 1 patient with recurrence underwent HV angioplasty at 26 months)	1 (1 patient with recurrence underwent HV stenting at 11 month post primary intervention)	4 (4 patients with recurrence underwent TIPS / DIPS revision at 9th, 34th, 37th, and 82nd months post primary intervention respectively)	2 (1 patient with clinical failure underwent hepatic stenting at 15 days post primary intervention, and 1 patient with recurrence underwent IVC angioplasty at 6th month)	–	–

IVC or hepatic veins angioplasty vs stenting did not show any statistical difference in early clinical outcome (p-value > 0.05). 8 out of 93 patients (8.6%) had primary clinical failure, which is defined as no clinical or laboratory improvement at 1 month follow up despite technical success, including 4 deaths (4.3%). One patient with primary clinical failure following IVC angioplasty had refractory ascites with patent IVC on angiogram. The patient was advised DIPS/TIPS or liver transplantation; however, consent was not provided. At the last follow up at 19 months post procedure, the patient had refractory ascites requiring repeated paracentesis. Three patients with clinical failure underwent reinterventions as described in Table 2, and good clinical response was noted in subsequent follow-up. Eighty-five of 93 patients (91.4%) had clinical success at 1 month, of whom 9 patients (9/93; 9.7%) had recurrence subsequently. All 9 patients with recurrence underwent reintervention, and good clinical response was noted in subsequent follow-up.

Complications and mortality: There were four deaths (4.3%) in the cohort, all occurring within 30 days of the index procedure. Three deaths were secondary to postprocedural liver failure in patients with severe hepatic dysfunction (MELD score > 18), and one death occurred due to hemopericardium following IVC angioplasty despite emergent surgical management. In addition, one patient experienced hepatic artery injury during TIPS/DIPS creation, which required transarterial embolization and was successfully managed without further sequelae. Overall, major procedure-related complications were observed in 5 of 93 patients (5.4%).

Predictors of Recurrence and Mortality: Exploratory comparison of demographic variables, pattern of venous involvement, and type of endovascular intervention did not identify any statistically significant predictors of recurrence or mortality (p > 0.05 for all comparisons). The number of recurrence events (n = 9) and mortality events (n = 4) was insufficient to support multivariate regression analysis. Therefore, recurrence and survival outcomes were interpreted descriptively rather than through predictive statistical modeling.

Long term clinical success of our study population (excluding events such as death, primary clinical failure, and recurrence) at 1 year, 3 year and 5 year was 84.5%, 79.7%, and 76.9% respectively, with mean duration of clinical success of 90.9 months (SD – 6 months; 95% CI – 79.1–102.7 months). Overall patency rate for endovascular intervention at 1 year, 3 year, and 5 year was 85.4%, 80.6%, and 77.8% respectively, with mean duration of patency of 91.9 months (SD – 6 months; 95% CI – 80.1–103.7 months). 1 year patency rate for isolated IVC recanalization, isolated hepatic veins recanalization, and combined IVC and hepatic vein recanalization was 84.5%, 83.5%, and 55.6% respectively, with respective mean patency duration of 83.8 months (SD – 6.7 months; 95% CI – 70.8–96.7 months), 93.3 months (SD – 9.9 months; 95% CI – 73.9–112.7 months), and 36.1 months (SD – 14.2 months; 95% CI – 8.2–64.2 months). 1 year, 3 year, and 5 year patency rate for entire recanalization group was 82.1%, 78.5%, and 78.5% respectively, with mean patency duration of 94.5 months (SD – 6.5 months; 95% CI – 81.6–107.2 months). DIPS / TIPS patency rate at 1 year, 3 years and 5 years was 92.4%, 84.7%, and 77% respectively, with mean patency duration of 69.4 months (SD – 5.9 months; 95% CI – 57.8–81 months). No statistically significant difference was seen between recanalization group and TIPS/DIPS group ($p = 0.843$). No statistically significant difference was seen between IVC recanalization, isolated hepatic vein recanalization, combined recanalization and TIPS / DIPS group ($p = 0.361$). 5 year survival rate of our entire study population was 95.6% (In our cohort, no deaths were noted after 6 months of follow up), with mean survival time of 112.9 months (SD – 2.5 months; 95% CI – 107.8–117.8 months). 5 year survival rate for isolated IVC recanalization, isolated hepatic veins recanalization, and TIPS/DIPS was 93.5%, 96.2%, and 96.4% respectively, with respective mean survival time of 91.7 months (SD – 4.3 months; 95% CI – 83.2–100.2 months), 113.5 months (SD – 4.4 months; 95% CI – 104.8–122.1 months), and 80.1 months (SD – 2.9 months; 95% CI – 74.4–85.7 months). No deaths were noted in combined IVC and hepatic veins recanalization group ($n = 7$). No statistically significant difference was seen between IVC recanalization, isolated hepatic vein recanalization, combined recanalization and TIPS / DIPS group ($p = 0.907$). 5 year survival rate of entire recanalization group was 95.2%, with mean survival time of 112.3 months (SD – 3.2 months; 95% CI – 106.1–118.6 months). No statistically significant difference was observed between recanalization and TIPS/DIPS group ($p = 0.8$) in our retrospective study (Fig. 6).

DISCUSSION

Budd-Chiari syndrome (BCS), though rare, represents a significant diagnostic and therapeutic challenge. Advances in radiological interventional techniques and hardware has changed the management protocol of BCS in favour of endovascular intervention with surgery being offered to patients not suitable for radiological interventions or having acute liver failure requiring liver transplantation (8). The present retrospective study of 93 patients at a high-volume tertiary care centre provides valuable insight into the anatomical patterns of BCS and the outcomes of percutaneous endovascular management strategies.

Consistent with previous studies from Asian populations, isolated IVC obstruction was the most frequent anatomical pattern (35.5%). This predominance of IVC pathology aligns with the findings by Hemachandran et al., Qiao et al. and Han et al. (9–11). In Asian cohorts, membranous and segmental IVC obstruction and combined IVC–hepatic venous disease are common, whereas in Western series hepatic vein thrombosis and sinusoidal type hepatic venous outflow obstruction typically predominate. The anatomical classification played a crucial role in procedural selection – IVC angioplasty and stenting were preferentially done for suprahepatic IVC disease, hepatic veins angioplasty and stenting for short-segment hepatic venous occlusion, while TIPS or DIPS was reserved for complex, multi-vessel long-segment hepatic venous occlusions.

The technical success rate of endovascular procedures in this study was exceptionally high (100%). A similar high technical success rate for endovascular intervention in Budd Chairi syndrome was noted in previous studies ranging from 86% to 100%(9–17), validating the procedural feasibility and reproducibility in experienced hands.

In our study, 28 patients (28/93; 30.1%) underwent TIPS/DIPS as a first procedure, attributed to higher proportion of patients with long segment hepatic venous occlusion. A previous large study from the Indian subset by Hemachandran et al. (29%) showed similar higher TIPS/DIPS intervention (29%) highlighting phenotypic variations in south Asian subpopulation (9). In our study, the primary clinical success rate at 1month was 91.4%. Similar studies in past has shown clinical success rates ranging from 73% to 97% (4, 9, 12–20).

The high 5 year survival rate observed in our study (95.6%) was comparable to other previous studies (11, 17–22). Meta-analysis by Mukhiya et al. reported a similar 5 year survival of 94.9% (95% CI: 92.9–96.9%) (15). No significant difference in 5 year survival rate was observed between recanalization group and TIPS/DIPS group in our study similar to results seen by Tripathi et al. (17). However, Hemachandran et al. reported a significant difference in 5 year survival rate between recanalization and TIPS groups in patients with combined IVC and hepatic vein occlusion, with the recanalization group demonstrating better outcomes (9).

Long-term results in our cohort were favourable, with 1 year, 3 year, and 5 year patency rates of 85.4%, 80.6%, and 77.8%, respectively, following endovascular intervention.

12 patients (12/93; 12.9%) required reintervention. Similar previous studies have reported comparable 1 year, and 5 year patency rate ranging between 85–95% and 66–81% respectively (9, 11, 13, 18, 19, 23, 24, 25). No clinically significant difference was seen between recanalization group and TIPS/DIPS group for patency rates, similar to findings reported by Hemachandran et al. (9).

Major procedure related complications were seen in 5 of our patients (5/93; 5.4%), including postprocedural liver failure ($n = 3$), hemopericardium ($n = 1$), and hepatic artery injury ($n = 1$). Other studies have reported major complications ranging from 0 to 20% (12, 17, 18, 21, 24, 25).

Wide variations in technical success rates, clinical success rates, patency rates, and complications between studies can be attributed to smaller sample size, and geographic variations in incidence of various phenotypes.

While overall outcomes in our cohort were favourable, it is important to emphasise that endovascular management of BCS is inherently complex and carries significant procedural risk. The deaths observed in our study, including one directly related to hemopericardium and the occurrence of hepatic artery injury

and multiple reinterventions highlight that these interventions should not be viewed as routine or universally low risk. Rather, they require substantial operator experience, multidisciplinary support, and institutional expertise. The high technical success and long term patency rates reported here likely reflect the fact that procedures were performed in a specialised high volume centre with dedicated proficiency in hepatic venous interventions. Therefore, these results may not be generalisable to centres with less experience or limited access to advanced interventional radiology infrastructure, and caution is warranted when extrapolating these findings to broader clinical settings.

This study has several limitations inherent to its retrospective design. First, Patient management was not randomised. Second, being a single-centre experience from a tertiary referral institute, the patient population may be subject to referral bias and may not reflect the broader spectrum of BCS presentations seen in primary or secondary care settings. Third, exclusion of patients without adequate clinical or imaging follow-up may have introduced survivorship bias, potentially overestimating long-term patency and clinical success rates. Fourth, the absence of standardized liver stiffness measurements or uniform histopathologic follow-up precluded a more objective correlation between intervention and hepatic fibrosis regression. Fifth, the treated population in our study was inherently heterogeneous, encompassing different anatomical subtypes of BCS (isolated IVC obstruction, isolated hepatic veins obstruction, long segment hepatic veins occlusion, and combined IVC and hepatic veins disease) as well as multiple interventional strategies (angioplasty alone, angioplasty with stenting, and TIPS/DIPS creation). Each of these subgroups has distinct pathophysiology, technical considerations, and expected clinical trajectories. This heterogeneity limits the ability to make direct comparisons between groups or to attribute outcomes solely to any single intervention type. As such, the general conclusions of the study should be interpreted with caution, and the reported success rates may not uniformly apply across all anatomical patterns or procedural categories. Sixth limitation relates to the imaging follow up strategy. Long term surveillance in our cohort was performed primarily using ultrasound and Doppler evaluation, with conventional venography or cross sectional imaging reserved only for patients in whom restenosis was suspected. While this approach reflects real world clinical practice and minimizes radiation and contrast exposure, it is inherently less sensitive than CT, MRI, or routine venographic surveillance for detecting subclinical restenosis or early in-stent dysfunction. As a result, radiological recurrence may have been underestimated, which could partially explain the high patency rates observed in our study. Seventh, the high technical success rate observed in our study should also be interpreted in the context of a high-volume tertiary referral centre with dedicated expertise in hepatic venous interventions. Most procedures were performed by experienced operators familiar with both recanalization and TIPS/DIPS workflows, with standardized pre-procedural imaging review and tailored selection of access routes, balloon size, and stent configurations. Similar centre-expertise-related influence on outcomes has been noted in previous Asian and European series (9, 11, 17). Hence, while the results are reproducible, technical success and complication rates may vary in lower volume settings where procedural familiarity and multidisciplinary support may differ. Eighth, dedicated TIPS stent was not used for our patients due to non-availability, and combination of covered and bare metal stent were used. It could have affected the patency rate for TIPS / DIPS procedure. Ninth, the study did not include a control group treated conservatively or by surgical shunting, thereby limiting direct comparative assessment of interventional radiology outcomes against alternative management strategies. These factors should be considered when generalizing the present findings to broader BCS populations and lower-volume practice settings. Future prospective, multicentre studies with uniform protocols and extended follow-up are warranted to validate and generalize these findings. Continued refinement in technique, hardware, and patient selection, along with standardized imaging and clinical follow-up protocols, will be crucial in optimizing and assessing long-term outcomes in BCS management.

In conclusion, this retrospective study involving 93 patients and more than a decade of experience treating Budd Chiari syndrome, reaffirms the pivotal role of interventional radiology in the management of BCS, particularly in south Asian regions with a high prevalence of membranous and segmental IVC obstruction. Recanalization procedures are safe and effective in the management of IVC obstruction and short segment hepatic veins occlusion, and are associated with high technical success, clinical success, and patency rates. TIPS/DIPS is reserved for patients with multiple long segment hepatic veins occlusions, and is associated with similar technical success, and clinical outcome. Recurrence is uncommon following endovascular intervention, and is often treatable by repeat intervention, with good outcome.

Declarations

Author Contribution

CJD contributed for patient selection, data collection, manuscript writing, and review. VK contributed for statistical analysis, manuscript writing, editing and review. IJ, SK, FS, and .S contributed for manuscript editing and review.

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Figures

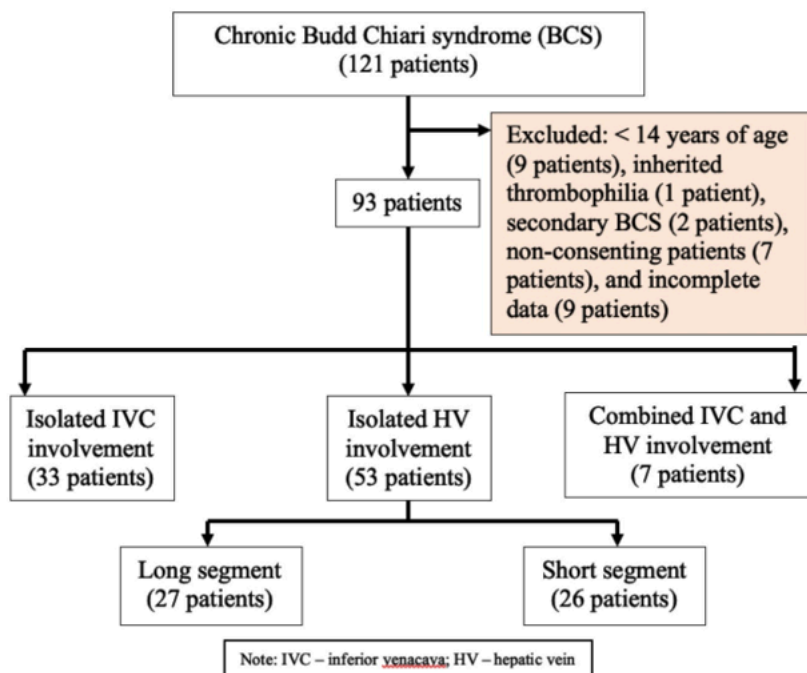


Figure 1
Patient selection flowchart

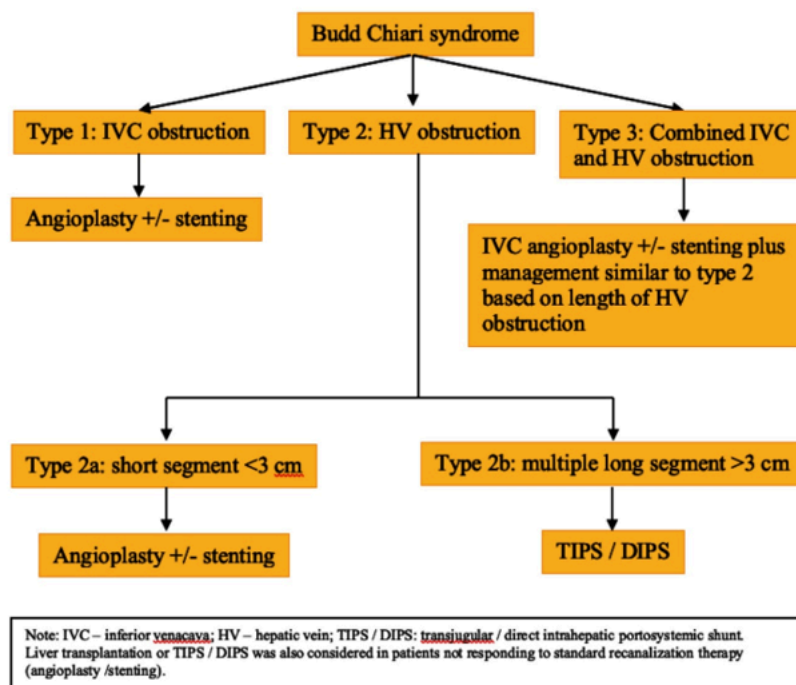


Figure 2
Institute protocol for management of Budd Chiari Syndrome

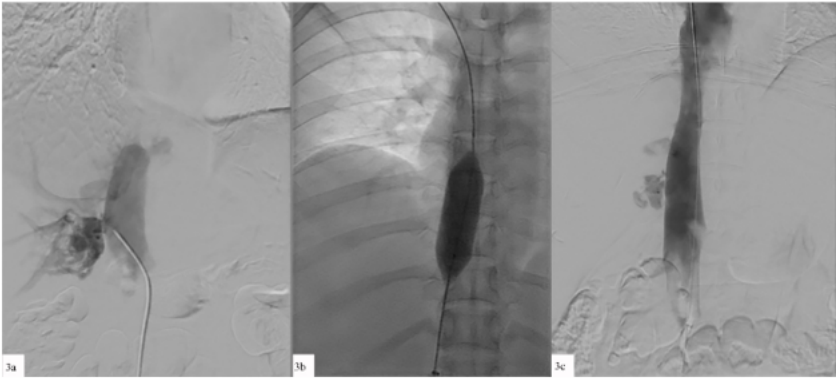


Figure 3

Balloon angioplasty for IVC obstruction (Type 1). Figure 3a shows short segment complete occlusion of suprahepatic IVC with filling up of collaterals. Balloon angioplasty was done for IVC obstruction using 20 x 80mm balloon catheter (3b) and post angioplasty venogram showed good flow across the stenosed segment (3c).



Figure 4

Hepatic vein stenting for short segment hepatic vein occlusion (type 2a). IVC venogram showed no IVC stenosis (4a). Small left hepatic vein ostial beak was seen with non-visualization of right hepatic vein ostium. Right hepatic vein was subsequently cannulated and balloon angioplasty was done using 8mm x 10mm balloon catheter (4b). 10mm x 40mm uncovered metallic stent was then placed in view of persistent significant stenosis after angioplasty (4c). Post stenting venogram (4d) and contrast enhanced CT (4e – arterial phase, 4f, 4g – venous phase) showed good flow across the hepatic vein stent.

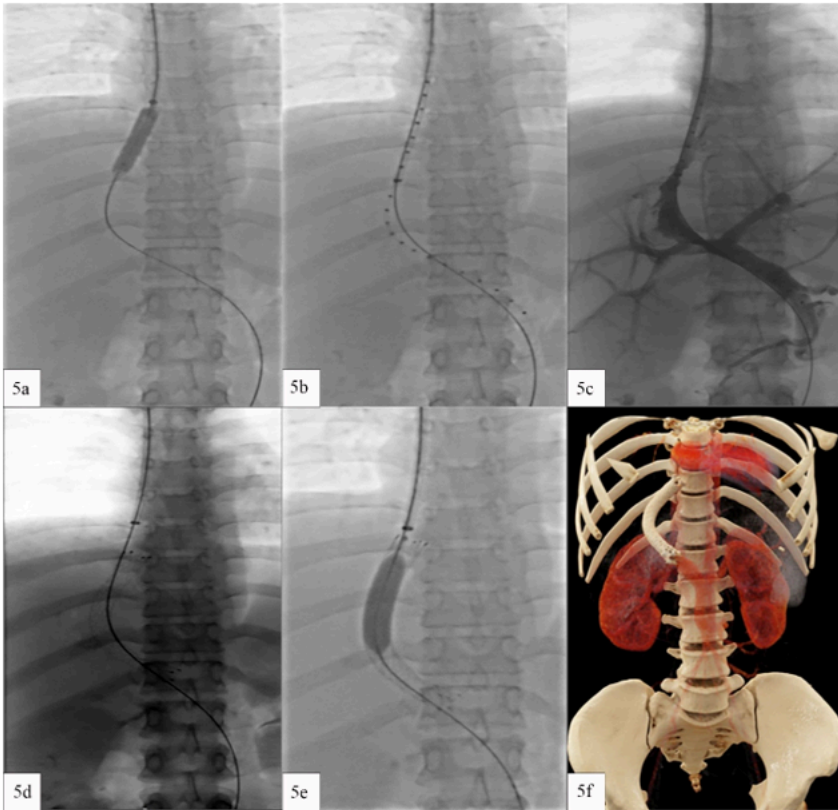


Figure 5

Trans-jugular intrahepatic portosystemic shunt (TIPS) for multiple long segment hepatic vein occlusion. Sequential fluoroscopic images depict TIPS creation - (5a) tract creation with balloon dilatation, (5b) placement of a marker pigtail catheter across the tract to measure the desired length of covered stent, (5c) contrast venogram showing intrahepatic tract following balloon dilatation, (5d) two stent deployment deployed across the tract (uncovered distal stent, and covered proximal stent), (5e) balloon dilatation of the deployed stent. (5f) cinematic volume-rendered CT image showing the final TIPS stent position bridging the portal and systemic venous systems.

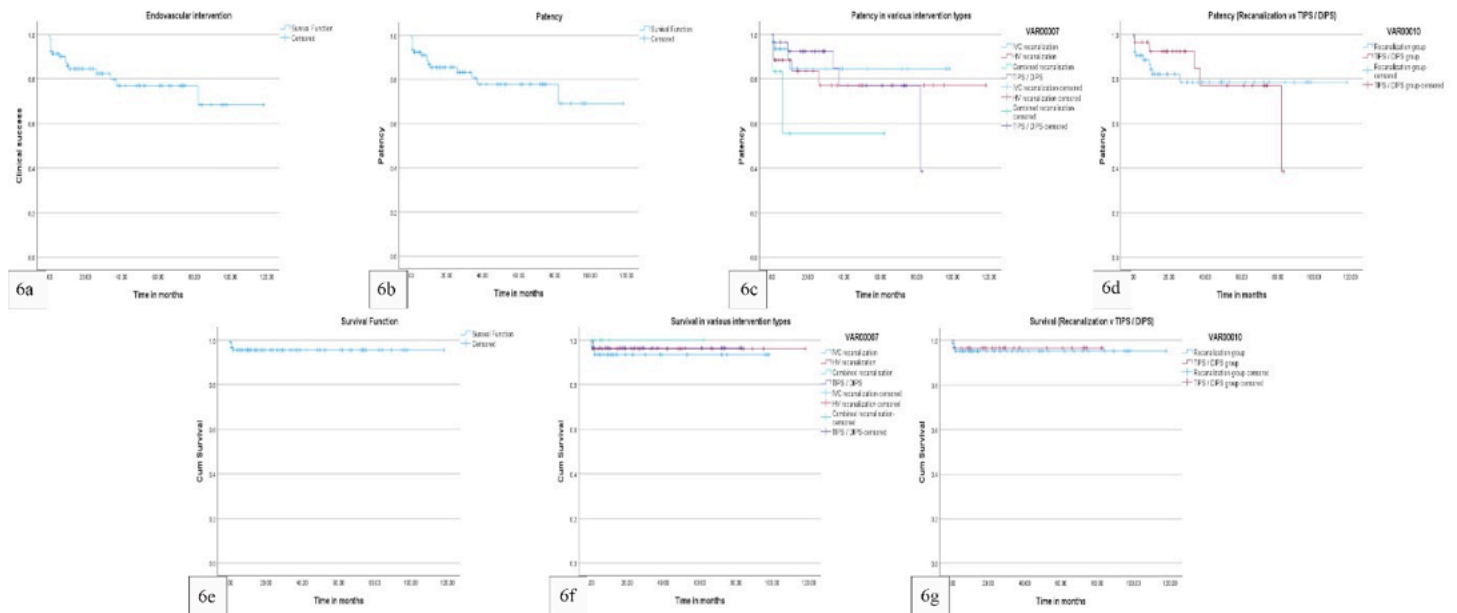


Figure 6

Kaplan Meier plots for - a) Cumulative clinical success rate of endovascular interventions; b) Cumulative patency rate of endovascular interventions; c) Patency rate in various types of endovascular interventions; d) Patency rate in recanalization group vs TIPS / DIPS group; e) Overall survival rate following

endovascular interventions; f) Survival rate in various endovascular intervention types; g) Survival rate in recanalization group vs TIPS / DIPS group. (IVC – inferior venacava; HV – **hepatic vein**; **TIPS / DIPS – Trans-jugular / Direct intrahepatic portosystemic shunt**)