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ORIGINAL ARTICLE

# Percutaneous recanalization for hepatic vein-type Budd-Chiari syndrome: long-term patency and survival

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**Abstract**
*Objective* To determine the long-term patency and survival of percutaneous recanalization for hepatic vein (HV)-type Budd-Chiari syndrome (BCS).
*Methods* From March 2009 to November 2014, consecutive symptomatic HV-type BCS patients were treated by percutaneous recanalization in our centers. These patients underwent main HV (MHV) or accessory HV (AHV) recanalization. Data on patient characteristics, technical success, clinical success, long-term patency, and survival were collected and analyzed.
*Results* During the enrolled periods, a total of 143 symptomatic HV-type BCS patients were treated by percutaneous recanalization in our centers. Technical success was achieved in 140 of 143 patients. One hundred eleven patients underwent MHV recanalization, and 29 underwent AHV recanalization. Clinical success was achieved in 136 of 140 patients. The mean MHV/AHV pressure decreased from $33.5 \pm 4.1$ mmHg before treatment to $12.5 \pm 3.1$ mmHg after treatment ($p = 0.000$). The 136 patients were followed for 7–75 months (mean $33.9 \pm 15.3$ months). Twenty-eight patients experienced re-obstruction of MHV ($n = 24$) or AHV ($n = 4$) at 3 to 36 months (mean $18.0 \pm 11.5$ months) after treatment. The cumulative 1-, 3-, and 6-year primary patency rates were 91.1, 77.4, and 74.0 %, respectively. The cumulative 1-, 3-, and 6-year secondary patency rates were 97.0, 92.4, and 88.8 %, respectively. The cumulative 1-, 3-, and 6-year survival rates were 97.7, 92.2, and 90.0 %, respectively.
*Conclusion* Percutaneous recanalization can provide good long-term patency and survival in HV-type BCS patients.

**Keywords** Hepatic vein · Budd-Chiari syndrome · Percutaneous recanalization · Long-term outcomes

## Introduction

Budd-Chiari syndrome (BCS) is a rare disease characterized by hepatic venous outflow obstruction [1–11]. According to the different obstructed sites, the BCS is divided into three types: (1) inferior vena cava (IVC)-type BCS is defined as IVC obstruction with at least one patent main hepatic vein (MHV); (2) hepatic vein (HV)-type BCS is defined as obstruction of the three MHVs; (3) combined-type BCS is defined as obstruction of both the IVC and three MHVs [1]. IVC-type BCS can easily be treated by IVC recanalization [2–4]. Approximately 86–89 % of combined-type BCS patients have a compensatory and patent accessory HV (AHV); therefore, single IVC recanalization is suitable for most combined-type BCS patients [5, 6].

The strategy for treating HV-type BCS patients is relatively complex. MHV recanalization is suitable for most HV-type BCS patients [7]. If MHV recanalization fails, a transjugular intrahepatic portosystemic shunt (TIPS) should be considered [8]. However, along with the in-depth research involving the AHV in BCS, AHV recanalization can be an effective method for HV-type BCS patients with a compensatory AHV [9–11]. Recently, the long-term

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outcome of percutaneous recanalization for HV-type BCS was still not known. In this study, we determined the long-term patency and survival of percutaneous recanalization for HV-type BCS.

## Materials and methods

### Patients selection

From March 2009 to November 2014, consecutive symptomatic HV-type BCS patients were treated by percutaneous recanalization in our centers. Patients were excluded if they had BCS secondary to a malignant tumor, asymptomatic BCS due to well-established intrahepatic collateral vessels, achieved clinical success of medical treatment only (anticoagulation and diuresis), or underwent TIPS, a surgical shunt, or liver transplant. Patients' baseline data before treatment included age, sex, symptoms, imaging findings, and laboratory examination findings.

### Diagnosis and preoperative evaluation

Diagnosis of HV-type BCS was established by reviewing patients' history, abdominal ultrasound findings, and abdominal magnetic resonance angiography (MRA)/computed tomography angiography (CTA) findings. All patients' blood samples were collected to check for BCS risk factors (JAK2 V167F mutation, protein C deficiency, protein S deficiency, and factor V Leiden mutation). Symptomatic BCS is defined as a BCS patient who has any one of the following clinical manifestations: abdominal pain, abdominal distention, jaundice, ascites, variceal bleeding, or encephalopathy [5].

Before treatment, the obstruction length of three MHVs was measured by MRA/CTA. Confirmation of the compensatory AHV by ultrasound and MRA/CTA was made before treatment. The AHV stem diameter was measured from the results of MRA/CTA. A compensatory AHV is defined as an AHV with its stem $\geq$5 mm [9]. If the patient had a compensatory but obstructed AHV, the obstruction length of the AHV was also measured by MRA/CTA. The membranous obstruction of MHV/AHV is defined as an obstruction length $\leq$1 cm, and segmental obstruction of MHV/AHV is defined as an obstruction length >1 cm [6]. The total obstruction of an MHV is defined as no visualization of MHV on MRA/CTA.

### Confirmation of the target vein

If the patient had no compensatory AHV, the target vein was the MHV. The target MHV was chosen with the one MHV with the shortest obstruction length. If the patient had a compensatory but obstructed AHV, we compared the obstruction length between three MHVs and the AHV, and the target vein was chosen with the one MHV or AHV with the shortest obstruction length.

### MHV and AHV recanalization

All patients were placed in the supine position. The blood pressure, heart rate, arterial oxygen saturation, and respiratory rate were monitored throughout the treatment. All procedures were performed by three interventional radiologists under fluoroscopic guidance.

If the target vein was the MHV, MHV recanalization was performed. MHV recanalization was routinely performed from the transjugular approach. If the transjugular MHV recanalization failed, the ultrasound-guided percutaneous transhepatic route would be used to access the MHV, and the MHV recanalization was performed via the combined transhepatic and transjugular approaches.

If the target vein was the AHV, AHV recanalization was performed. The approach to AHV recanalization depended on the angle between the ostium of the AHV and distal side of the IVC. The femoral vein approach was used if the angle was obtuse or right. Otherwise, the jugular vein approach was used. If the transjugular or transfemoral AHV recanalization failed, the ultrasound-guided percutaneous transhepatic route was used to access the AHV and the AHV recanalization performed via the combined transhepatic and transjugular/transfemoral approaches.

Percutaneous recanalization was performed with the balloon or stent. Stent insertion was performed if there was >30 % residual stenosis after balloon dilation. MHV or AHV pressure was measured by a piezometer tube before and after recanalization. After treatment, all patients received subcutaneous low-molecular-weight heparin (5000 IU, twice a day) for 3 days, followed by oral warfarin for 12 months. The dose of warfarin was adjusted to maintain the international normal ratio of 2–3.

### Definitions and endpoints

Technical success of percutaneous recanalization was defined as the MHV/AHV being restored at venography with the disappearance of intrahepatic collateral vessels. Clinical success was defined as the symptoms and liver function tests improving after technical success of percutaneous recanalization [5]. Re-obstruction was defined as no or retrograde flow being present in the lumen or if the degree of lumen obstruction was >30 % with intrahepatic collateral vessels on ultrasound examination [5]. Re-obstruction was suspected if the BCS-related symptoms reappeared.

All patients underwent abdominal ultrasound and clinical examination 7 days, 1, 3, 6, and then every 6 months after treatment to confirm the long-term patency. The primary endpoint was re-obstruction of the target vein. The secondary endpoints included anticoagulation-related bleeding and death. The follow-up ended at the patients' death, the point of undergoing TIPS, surgical shunt, or liver transplant, the point of being lost to follow-up, or the point of setting this study (June 2015).

### Statistical analysis

Continuous variables are summarized as the mean ± standard deviation. The paired samples $t$ test was performed to compare variables before and after treatment. Categorical variables are compared by the chi-square test or Fisher's exact test. Cumulative patency and survival rates were calculated by using Kaplan-Meier curves. The predictors of re-obstruction were determined using univariate and multivariate Cox regression analysis. The covariates incorporated into the multivariate analysis were the variables with $p < 0.1$ on univariate analysis. A $p$ value $<0.05$ was considered statistically significant. All statistical calculations were performed using SPSS 16.0 (SPSS, Chicago, IL, USA).

## Results

### Patients

During the enrolled periods, 143 symptomatic HV-type BCS patients were treated by percutaneous recanalization in our centers. Three patients had hepatic cellular carcinoma (HCC). However, the HCC was not the cause of BCS, so they were not excluded. All patients received medical treatment (anticoagulation and diuresis) for 1 week before percutaneous recanalization, but no patient responded to medical treatment.

### Technical success

Technical success was achieved in 140 (97 %) of 143 patients. Four patients experienced mild hematoma at the right jugular region, and they were treated with local pressure. Three patients failed to undergo MHV recanalization because of total obstruction of three MHVs. They were treated with TIPS insertion. One hundred eleven patients underwent MHV recanalization, and 29 underwent AHV recanalization. Among the 29 patients who underwent AHV recanalization, 11 had the total obstruction of three MHVs. One hundred twenty-four patients underwent balloon dilation, and 16 underwent stent insertion. The balloons were 10–14 mm in diameter and 40 mm in length (Cook, Bloomington, IN, USA, or Bard, Murray Hill, NJ, USA). The stents were Zilver stents (Cook) or Luminexx stents (Bard) with a diameter of 10–14 mm and length of 40–60 mm.

### Clinical success

Clinical success was achieved in 136 (97 %) of 140 patients. The mean MHV/AHV pressure decreased from 33.5 ± 4.1 mmHg before treatment to 12.5 ± 3.1 mmHg after treatment ($p = 0.000$). Four patients (3 with MHV recanalization and 1 with AHV recanalization) experienced clinical failure due to the decompensated liver cirrhosis, and they were treated with TIPS insertion. The baseline data and treatment details of these 136 patients are demonstrated in Tables 1 and 2, respectively.

### Patency

The 136 patients were followed for 7–75 months (mean 33.9 ± 15.3 months). No patient was lost to follow-up. Twenty-eight patients experienced re-obstruction of the MHV ($n = 24$) or AHV ($n = 4$) 3–36 months (mean 18.0 ± 11.5 months) after treatment. There was no significant difference in re-obstruction between patients who underwent MHV and AHV recanalization (24/124 vs. 4/28, $p = 0.532$). There was no significant difference in re-obstruction between patients with and without stent insertion (6/16 vs. 22/120, $p = 0.075$). Among the 28 patients, 26 underwent repeat percutaneous recanalization (balloon dilation: 18; stent: 8); the remaining 2 underwent TIPS insertion because of the refractory gastrointestinal bleeding. The cumulative 1-, 3-, and 6-year primary patency rates were 91.1, 77.4, and 74.0 %, respectively. The cumulative 1-, 3-, and 6-year secondary patency rates were 97.0, 92.4, and 88.8 %, respectively (Fig. 1).

At univariate analysis, the predictors of re-obstruction were preoperative gastrointestinal bleeding, segmental obstruction of the target vein, a higher alkaline phosphatase level, lower albumin level, higher creatinine level, and higher cancer antigen 125 level. At multivariate analysis, the independent predictor of re-obstruction was segmental obstruction of the target vein (hazard ratio: 2.557, 95 % confidence interval: 1.092–5.986, $p = 0.031$, Table 3).

### Survival

Nine patients died 8–38 months (medium 15 months) after treatment. The causes of death included hepatic failure ($n = 4$), HCC ($n = 3$), and gastrointestinal hemorrhage ($n = 2$). The hepatic failure and gastrointestinal hemorrhage occurred after the second re-obstruction of MHV ($n = 5$) or AHV ($n = 1$). The cumulative 1-, 3-, and 6-year

**Table 1** Baseline data of the 136 patients with technical and clinical success

| | Values |
|---|---|
| Age (years) | 32.6 ± 10.7 (14–72) |
| Sex (male/female) | 58/78 |
| Duration of symptoms (months) | 13.1 ± 8.4 (1–36) |
| Risk factors | |
| JAK2 V167F mutation | 5 |
| Protein C deficiency | 0 |
| Protein S deficiency | 0 |
| Factor V Leiden mutation | 0 |
| Clinical manifestations | |
| Abdominal distention | 136 |
| Abdominal pain | 46 |
| Ascites | 130 |
| Jaundice | 16 |
| Gastrointestinal bleeding | 12 |
| Liver cirrhosis | 18 |
| HBV/HCV/HIV infection | 3/0/0 |
| Imaging finding | |
| Combined compensatory AHV | 28 |
| Right MHV obstruction (MO/SO) | 38/98 |
| Middle MHV obstruction (MO/SO) | 34/102 |
| Left MHV obstruction (MO/SO) | 14/122 |
| AHV obstruction (MO/SO) | 28/0 |
| Laboratory tests | |
| Prothrombin time (PT, s) | 16.4 ± 3.0 (11.8–28.9) |
| International normalized ratio (INR) | 1.3 ± 0.3 (0.9–2.2) |
| Aspartate aminotransferase (AST, U/l) | 40.3 ± 59.3 (6–315) |
| Alanine aminotransaminase (ALT, U/l) | 45.5 ± 59.7 (11–349) |
| Alkaline phosphatase (ALP, U/l) | 130.5 ± 45.4 (48–293) |
| Total bilirubin (TBIL, μmol/l) | 41.3 ± 36.8 (16.8–280.2) |
| Albumin (g/l) | 36.3 ± 6.4 (22.6–47.3) |
| Creatinine (μmol/l) | 60.6 ± 19.5 (34–122) |
| Alpha fetoprotein (AFP, μg/l) | 5.1 ± 10.0 (0.6–100.2) |
| Carcinoembryonic antigen (CEA, ng/ml) | 1.9 ± 1.2 (0.3–6.7) |
| Cancer antigen 125 (CA125, U/ml) | 140.6 ± 106.7 (11.4–487.1) |
| Cancer antigen 19-9 (CA19-9, U/ml) | 14.9 ± 10.0 (0.1–68.9) |
| Child-Pugh score | 8.1 ± 1.9 (5–12) |
| BCS-TIPS score | 10.1 ± 5.9 (5.7–48.0) |
| Rotterdam score | 1.0 ± 0.5 (0.1–2.2) |
| New Clichy score | 4.8 ± 2.0 (2.4–8.2) |

*AHV* accessory hepatic vein, *MHV* main hepatic vein, *MO* membranous obstruction, *SO* segmental obstruction

survival rates were 97.7, 92.2, and 90.0 %, respectively (Fig. 2).

## Discussion

This study demonstrated our clinical results of percutaneous recanalization for HV-type BCS patients. The technical and clinical success rates (97 and 97 %, respectively) were comparable to previous studies involving percutaneous recanalization for HV-type BCS patients [12, 13]. These results may indicate that percutaneous recanalization is suitable for most HV-type BCS patients.

In the West, a majority of BCS patients are HV-type BCS patients [14–16]. While in Asia, approximately 11–28 % of BCS patients are HV-type BCS patients [1, 5]. The purpose of MHV/AHV recanalization is to relieve

**Table 2** Details of treatment procedures

| | MHV recanalization group ($n = 108$) | AHV recanalization group ($n = 28$) |
|---|---|---|
| Balloon dilation | 97 | 23 |
| Stent insertion | 11 | 5 |
| Target MHV | | |
| Right | 57 | – |
| Middle | 34 | – |
| Left | 17 | – |
| Treatment approach | | |
| Transjugular | 82 | 17 |
| Transfemoral | – | 8 |
| Combined transhepatic and transjugular | 26 | 2 |
| Combined transhepatic and transfemoral | – | 1 |
| Nature of obstruction of target vein | | |
| Membranous obstruction | 88 | 28 |
| Segmental obstruction | 20 | 0 |

*MHV* main hepatic vein, *AHV* accessory hepatic vein

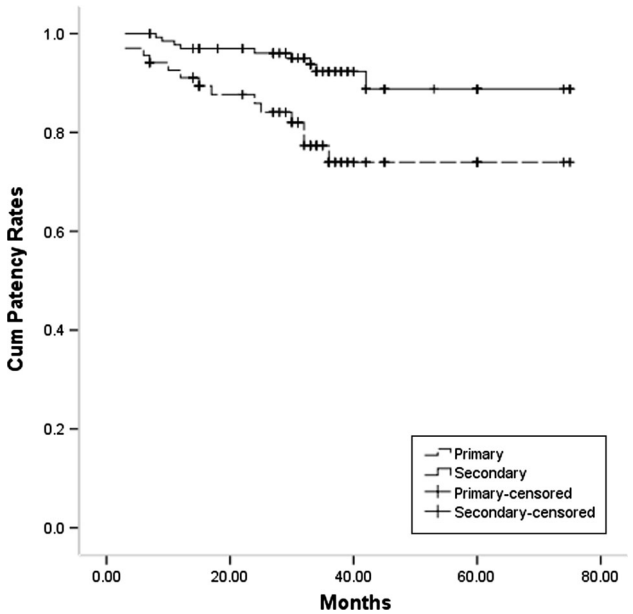


**Fig. 1** Primary and secondary patency rates after treatment

liver congestion, relieve patients' symptoms, and improve liver functions [7–13]. In this study, we performed single MHV/AHV recanalization for our patients. Single MHV/AHV can afford draining the entire liver because of the well-established intrahepatic collateral vessels in the liver of BCS patients [1, 9–11].

Compensatory AHV is a compensatory mechanism in BCS patients [9–11]. Approximately 71 % of BCS patients have compensatory AHV, and approximately 78 % of AHVs are patent [9]. In this study, we found all of the AHV obstruction was membranous obstruction. This result may be attributed to the AHV obstruction occurring because the ostium of the AHV is restricted by the IVC wall and does not dilate along with the AHV stem dilation [9]. If the BCS patients have the segmental obstruction of three MHVs but a compensatory AHV, AHV recanalization can help the patients to avoid TIPS insertion [9–11].

Qi et al. [17] reported the use of TIPS for BCS in Chinese patients. In this study, TIPS insertion was performed for seven patients who experienced technical failure ($n = 3$) or clinical failure ($n = 4$) of percutaneous recanalization. The main indications of TIPS insertions for HV-type BCS were unsuccessful and ineffective percutaneous recanalization.

The cumulative 1-, 3-, and 6-year primary patency rates were 91.1, 77.4, and 74.0 %, respectively. These rates are comparable to previous studies involving percutaneous recanalization for HV-type BCS patients [12, 13]. We further found an excellent cumulative 6-year secondary patency rate of 88.8 %, which supports percutaneous recanalization being well repeatable. We also found that the independent predictor of re-obstruction of HV/AHV was segmental obstruction of the target vein. This risk factor is similar to re-obstruction of IVC in a study involving percutaneous recanalization for IVC-type BCS [2].

The cumulative 1-, 3-, and 6-year survival rates were 97.7, 92.2, and 90.0 %, respectively. Re-obstruction is considered to be the risk factor of death in BCS patients after percutaneous recanalization [5]. BCS patients are in need of regular follow-up after percutaneous recanalization. If the patients experience re-obstruction, re-intervention should be performed in a timely fashion to decrease the mortality.

In this study, we found that percutaneous recanalization was suitable for 95 % (136 of 143) of HV-type BCS patients. A retrospective study involving interventional treatment demonstrated that percutaneous recanalization was only suitable for 51 % (31 of 61) of BCS patients in the West [18]. The main indication of percutaneous recanalization of BCS is membranous or short length obstruction of MHV or AHV [9, 18]. In Asia, most BCS patients have membranous obstruction of the MHV [19]. However, membranous obstruction or short length obstruction of MHV was only identified in 29–41 % of BCS patients in the West [18, 20]. This phenomenon may explain the different applicability rates of percutaneous recanalization for BCS between the present study and studies of BCS patients in the West.

**Table 3** Univariate and multivariate analysis for re-obstruction

| | Univariate analysis | | | Multivariate analysis | | |
|---|---|---|---|---|---|---|
| | Hazard ratio | 95 % CI | *p* value | Hazard ratio | 95 % CI | *p* value |
| Age | 0.654 | 0.301–1.419 | 0.283 | | | |
| Sex | 0.970 | 0.933–1.009 | 0.130 | | | |
| Duration | 0.988 | 0.943–1.036 | 0.619 | | | |
| Gastrointestinal bleeding | 2.408 | 0.974–5.959 | 0.057 | 1.882 | 0.714–4.960 | 0.201 |
| Segmental obstruction | 3.938 | 1.811–8.562 | 0.001 | 2.557 | 1.092–5.986 | 0.031 |
| Prothrombin time | 1.067 | 0.950–1.200 | 0.273 | | | |
| International normalized ratio | 1.670 | 0.483–5.766 | 0.418 | | | |
| Aspartate aminotransferase | 1.001 | 0.996–1.006 | 0.631 | | | |
| Alanine aminotransaminase | 0.999 | 0.992–1.006 | 0.751 | | | |
| Alkaline phosphatase | 1.006 | 0.999–1.013 | 0.099 | 1.007 | 0.999–1.014 | 0.071 |
| Total bilirubin | 0.981 | 0.956–1.006 | 0.134 | | | |
| Albumin | 0.902 | 0.848–0.960 | 0.001 | 0.941 | 0.878–1.007 | 0.080 |
| Creatinine | 1.108 | 1.004–1.033 | 0.012 | 1.012 | 0.995–1.029 | 0.162 |
| Alpha fetoprotein | 0.983 | 0.921–1.049 | 0.600 | | | |
| Carcinoembryonic antigen | 0.932 | 0.665–1.305 | 0.681 | | | |
| Cancer antigen 125 | 1.006 | 1.002–1.009 | 0.001 | 1.003 | 1.000–1.007 | 0.075 |
| Cancer antigen 19-9 | 1.012 | 0.979–1.047 | 0.476 | | | |
| Stent | 2.140 | 0.865–5.291 | 0.100 | | | |
| Child-Pugh score | 1.133 | 0.973–1.370 | 0.199 | | | |
| BCS-TIPS score | 0.942 | 0.841–1.056 | 0.307 | | | |
| Rotterdam score | 1.462 | 0.627–3.412 | 0.380 | | | |
| New Clichy score | 1.140 | 0.947–1.372 | 0.165 | | | |

*CI* confidence interval

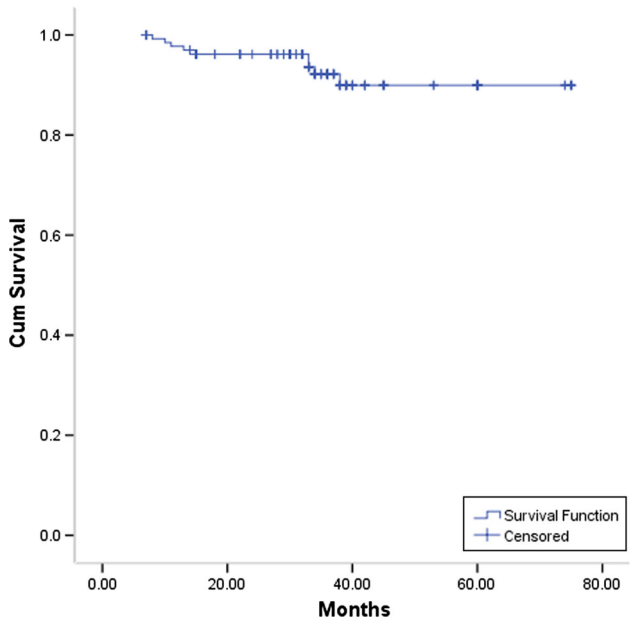


**Fig. 2** Survival rates after treatment

This study has some limitations. First, the biggest limitation is its retrospective nature. Further randomized controlled trials should be performed. Second, there is no control group in this study. However, we aimed to evaluate the long-term outcomes of percutaneous recanalization for HV-type BCS patients. Third, the sample size is not large.

In conclusion, although further randomized controlled trials are needed, our results demonstrated that percutaneous recanalization can provide good long-term patency and survival in HV-type BCS patients.

**Compliance with ethical standards**

**Conflicts of interest** Yan-Feng Cui, Yu-Fei Fu, De-Chun Li, and Hao Xu declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For this type of study formal consent is not required. This article does not contain any studies with animals performed by any of

the authors. This was a retrospective study approved by our Institutional Review Board. Each patient received the details about percutaneous recanalization and provided written informed consent for percutaneous recanalization before treatment.

**Informed consent** Informed consent was obtained from all individual participants included in the study.

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