Radiol med (2015) 120:1094–1099
DOI 10.1007/s11547-015-0554-9

ABDOMINAL RADIOLOGY

Combined thrombus aspiration and recanalization in treating Budd–Chiari syndrome with inferior vena cava thrombosis

Yu-Fei Fu[1] · Hao Xu[2] · Qian Wu[3] · Qing-Qiao Zhang[2] · Yan-Feng Cui[2] · Ning Wei[2]

Received: 9 January 2015 / Accepted: 7 May 2015 / Published online: 24 May 2015

Abstract
Purpose To investigate the feasibility, safety, and effectiveness of combined thrombus aspiration and inferior vena cava (IVC) recanalization for Budd–Chiari syndrome (BCS) patients with IVC thrombosis.
Materials and methods From March 2011 to October 2014, 17 consecutive BCS patients with IVC thrombosis [male 13, female 4 (mean age 52.6 ± 8.4 years, range 43–72 years)] treated by combined thrombus aspiration and IVC recanalization were enrolled in this retrospective study. An 8F guiding catheter was used as the aspiration catheter. During the treatment, the aspiration catheter was placed from the right femoral vein to the IVC thrombi, and a 20-ml syringe was connected with the aspiration catheter for thrombus aspiration. IVC recanalization was performed after thrombus aspiration. Data on technical success, clinical success, and follow-up were analyzed.
Results Technical success was achieved in all patients. After thrombus aspiration, 12 patients had no visible thrombi on IVC venography, while 5 patients were shown to have the IVC mural thrombi. Afterwards, 13 patients were treated by IVC balloon dilation, and 4 patients were treated by IVC stent insertion. No patient experienced dyspnea after treatment. The average IVC pressure decreased from 29.8 ± 3.4 cmH_2O to 8.6 ± 2.1 cmH_2O ($P < 0.001$). Clinical success was achieved in all patients. The average follow-up period was 15.3 ± 11.6 months (range 2–44 months). Long-term IVC patency was achieved in 15 of 17 patients.
Conclusion Combined thrombus aspiration and IVC recanalization can be a safe and effective method for BCS patients with IVC thrombosis.

Keywords Budd–Chiari syndrome · Inferior vena cava · Thrombosis · Aspiration

Introduction

Budd–Chiari syndrome (BCS) is a rare disease involving hepatic venous outflow obstruction at the level of hepatic vein (HV), inferior vena cava (IVC), or both [1–4]. Approximate 20 % of BCS patients have the IVC thrombosis involvement of IVC [3]. Standard IVC recanalization (balloon dilation/stent insertion) is considered to be a contraindication in these patients because of the risk of acute fatal pulmonary embolism (PE) [4].

Currently, combined catheter direct thrombolysis and IVC recanalization is widely used for BCS patients with IVC thrombosis [4–6]; however, catheter direct thrombolysis requires a long treatment period and has the attendant risk of hemorrhage, especially for patients with upper gastrointestinal bleeding. To overcome this problem, we used the thrombus aspiration technique to manage IVC thrombosis before IVC recanalization. The aim of this study was to assess the feasibility, safety, and effectiveness of combined thrombus aspiration and IVC recanalization for BCS patients with IVC thrombosis.

Y.-F. Fu, H. Xu and Q. Wu contribute equally to this study.

✉ Ning Wei
weiningjieru@163.com

[1] Department of Radiology, Xuzhou Central Hospital, Xuzhou, China

[2] Department of Interventional Radiology, Affiliated Hospital of Xuzhou Medical College, Xuzhou, China

[3] Department of Nuclear Medicine, Xuzhou Central Hospital, Xuzhou, China

Table 1 Baseline data of the 17 patients who underwent combined thrombus aspiration and IVC recanalization

No./age (years)/gender	Clinical manifestations	Duration (months)	Patency of hepatic vein	IVC thrombus			Liver function (Child-Pugh)
				Length (mm)	Diameter (mm)	Nature	
1/52/female	A, AD, H, LP	15	RHV, AHV	65	22	Mixed	B
2/72/male	A, AD, LP	3	RHV	40	19	Fresh	B
3/65/male	A, AD, AP, LP	9	AHV	36	20	Old	B
4/43/female	A, AD, AP, H, LP	36	RHV, MHV	55	20	Mixed	A
5/56/male	A, AD, LP	6	AHV	100	23	Fresh	B
6/49/male	A, AD, AP	1	AHV	60	25	Fresh	C
7/63/male	A, AD, H, LP	23	LHV, RHV	30	15	Mixed	B
8/56/male	A, AD, AP, H, LP	28	LHV, MHV	45	18	Mixed	B
9/45/male	A, AD, LP	12	AHV	30	20	Mixed	C
10/56/female	A, AD, LP	18	AHV	43	20	Mixed	A
11/45/male	A, AD, AP, H, LP	16	RHV	62	23	Mixed	B
12/43/male	A, AD, AP, H	8	RHV	63	21	Mixed	A
13/51/male	A, AP, H, LP	11	MHV	30	17	Old	A
14/56/male	A, AD, AP, H, LP	19	AHV	36	19	Old	B
15/43/male	A, AD, LP	9	RHV	48	22	Mixed	B
16/46/female	A, AP, H, LP	5	MHV	53	21	Mixed	B
17/53/male	A, AD, H, LP	12	AHV	33	16	Old	B

A ascites, *AD* abdominal distention, *AP* abdominal pain, *H* hepatomegaly, *LP* lower limbs pigmentation, *Duration* duration of symptoms at diagnosis, *RHV* right hepatic vein, *LHV* left hepatic vein, *MHV* middle hepatic vein, *AHV* accessory hepatic vein, *IVC* inferior vena cava

Materials and methods

This was a single-center retrospective study. Our Institutional Review Board approved this study. Before treatment, each patient received detailed information of combined thrombus aspiration and IVC recanalization, and provided the informed consent.

Patients and diagnosis

From March 2011 to October 2014, 17 consecutive BCS patients with IVC thrombus [male 13, female 4 (mean age 52.6 ± 8.4 years, range 43–72 years)] were treated by combined thrombus aspiration and IVC recanalization in our center (Table 1). All patients came to our center for primary treatment of BCS. None of these patients had a cardiopulmonary disease. The risk factors of BCS, including JAK2 mutation, factor V Leiden mutation, protein C deficiency, and protein S deficiency, were not present in any of these patients. None of these patients had an autoallergic disease or malignant tumor. The main clinical manifestations included abdominal distention, abdominal pain, ascites, hepatomegaly, and lower limb pigmentation. The duration of symptoms in these patients was 1–36 months (average 13.6 ± 9.2 months). Patients' liver function was evaluated by Child-Pugh grade (A 4, B 11, C 2).

The diagnosis of BCS was established on patients' history and results of abdominal ultrasonography and magnetic resonance imaging (MRI). The diagnosis of IVC thrombosis was established on the results of abdominal ultrasonography and MRI. The length and diameter of IVC thrombus were measured from MRI. The average length and diameter of the IVC thrombi were 48.8 ± 18.0 mm (range 30–100 mm) and 20.1 ± 2.6 mm (range 15–25 mm), respectively. Concerning the nature of thrombus, 3 patients had fresh thrombus, 10 patients had mixed thrombus, and 4 patients had old thrombus. The nature of IVC thrombi was differentiated by MRI [7]. All patients had at least one patent HV or accessory HV.

Aspiration catheter

Thrombus aspiration was performed using an aspiration catheter. The catheter was a commonly used 8F Brite-Tip guiding catheter (Cordis, Hialeah, FL, USA).

IVC thrombus aspiration

All procedures were performed by three interventional radiologists with 3, 8, and 16 years of interventional procedures experience under fluoroscopic and local anesthesia. The blood pressure, heart rate, respiratory rate, and arterial

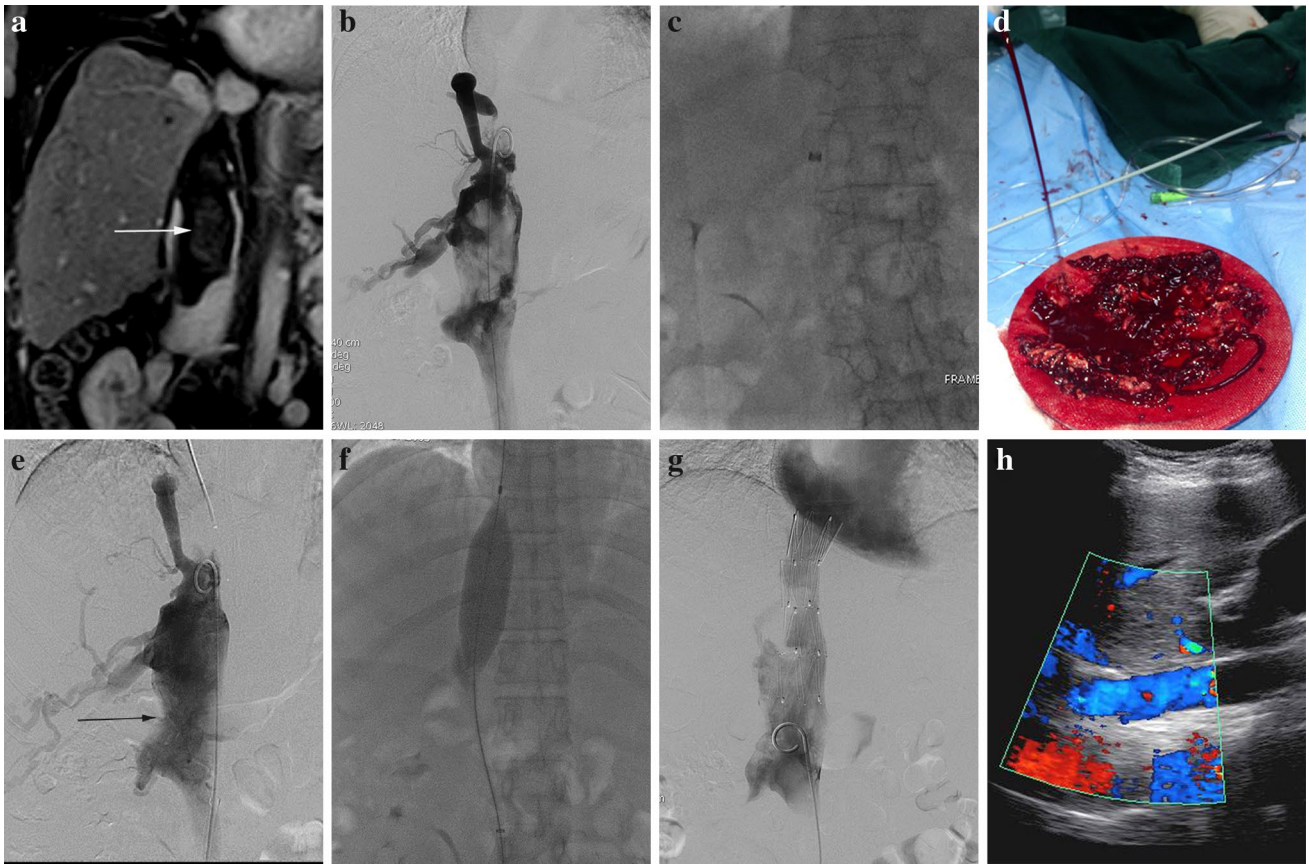

Fig. 1 Combined thrombus aspiration and IVC recanalization was performed in a 52-year-old female with BCS and IVC thrombosis. **a** The preoperative MRI showed a mixed IVC thrombi (*arrow*). **b** IVC venography confirmed the thrombi. **c**, **d** The guiding catheter was used to aspirate the thrombi. **e** IVC venography showed persistent mural thrombi (*arrow*) after thrombus aspiration. **f**, **g** Blood flowed from IVC to right atrium smoothly after balloon dilation and stent insertion. **h** Abdominal Doppler ultrasonography showed the patency of IVC at 3 months after treatment

oxygen saturation were monitored throughout the entire procedure.

An 8F catheter sheath was placed in the right femoral vein, and a 5F Pigtail catheter (Cordis, Hialeah, FL, USA) was advanced into IVC for venography. The IVC thrombosis was confirmed by venography, and we rapidly injected 20 ml of physiologic saline and 100,000 unit of urokinase (Biochem, Tianjin, China) via the Pigtail catheter into IVC to loosen the thrombi.

The Pigtail catheter was withdrawn, and the aspiration catheter was advanced to the level of thrombi. The catheter was pushed forth and back, and simultaneously rotated at the area of the thrombus to facilitate the thrombus aspiration. A 20-ml syringe was connected with the catheter for thrombus aspiration (Fig. 1). When only blood was aspirated, we removed and washed the catheter. The IVC venography was performed to confirm the effectiveness of thrombus aspiration, and the position of the aspiration catheter was adjusted based on the result of IVC venography. The endpoint of thrombus aspiration was as follows: (a) no thrombi visible on IVC venography; and (b) persistence of not removable mural thrombi.

If the syringe was difficult to suction, it was suspected that the thrombi were at the tip of the catheter. We thus removed and washed the catheter. In case of the thrombi persisting at the valve of the catheter sheath, we advanced a guide wire through the sheath into the femoral vein and retained the guide wire. Then, the catheter sheath was advanced again to the femoral vein via the guide wire.

IVC recanalization

After thrombus aspiration, the right jugular vein was punctured and a 5F catheter sheath was placed. A 4F angled-tip catheter (Cordis, Hialeah, FL, USA) was advanced to the proximal end of IVC to perform the venography. Then a J-type steel needle (Cook, Bloomington, IN. USA) was used to puncture the IVC obstruction from top-to-bottom. When this was achieved, the IVC recanalization was performed with a 26–30-mm-diameter balloon (Cook,

Table 2 Results of treatment and outcome of these 17 patients

No.	Residual visible thrombus after aspiration	Time of thrombus aspiration (min)	IVC recanalization	IVC pressure (cmH_2O)		Follow-up (months)	Re-obstruction
				Before	After		
1	Yes	8	Stent	33	10	13	No
2	No	6	Balloon dilation	29	7	2	No
3	Yes	8	Balloon dilation	22	5	18	No
4	No	8	Balloon dilation	35	11	9	No
5	No	11	Stent	26	9	44	No
6	No	8	Stent	30	11	7	No
7	No	6	Balloon dilation	28	6	29	Yes
8	No	6	Balloon dilation	32	8	15	No
9	No	5	Balloon dilation	29	8	5	No
10	No	8	Balloon dilation	35	11	31	No
11	Yes	9	Balloon dilation	26	9	3	No
12	No	8	Balloon dilation	30	11	12	Yes
13	No	9	Balloon dilation	31	9	8	No
14	Yes	7	Stent	34	11	11	No
15	No	6	Balloon dilation	29	8	7	No
16	No	8	Balloon dilation	28	5	29	No
17	Yes	10	Balloon dilation	29	8	17	No

IVC inferior vena cava

Bloomington, Ind. USA) or a 28–30-mm-diameter Z-type stent (Yongtong, Shenyang, China; Fig. 1). The stent insertion was needed if there was more than 30 % residual stenosis of IVC after balloon dilation [2]. The IVC pressure was measured using the angiography catheter and piezometric tube before and after IVC recanalization, respectively. Because all patients had at least one patent HV or accessory HV, the patients did not undergo HV recanalization.

After treatment, all patients received subcutaneous low-molecular-weight heparin for 3 days, followed by warfarin sodium for 12 months. The international normalized ratio was maintained at 2–3.

Definitions and end points

Technical success of combined thrombus aspiration and IVC recanalization was defined as elimination of the IVC obstruction and collateral circulation as determined by IVC venography without any major procedure-related complications. The major and minor complications were defined according to the guidelines of the Society of Interventional Radiology [8]. Clinical success was defined as an improvement in BCS-related manifestations after treatment. Patients underwent abdominal Doppler ultrasonography and physical examination at 7 days, 1 month, 3 months, and every 6 months after treatment to confirm the long-term patency of the IVC. Respiratory function after treatment was also monitored. If patients felt chest congestion or dyspnea, chest computed tomography (CT) was performed to confirm whether or not there was a PE. The primary end point was IVC re-obstruction. The secondary end points included PE, anticoagulation-related bleeding, and death.

Statistical analysis

Continuous variables were summarized as the mean ± standard deviation. The paired samples *t* test was performed to compare variables before and after treatment. A P value <0.05 was considered statistically significant. All statistical calculations were performed using SPSS 16.0 (SPSS, Chicago, IL, USA).

Results

Assessment of treatment

Combined thrombus aspiration and IVC recanalization was technically successful in all of the patients (Table 2). One patient developed a hematoma in the right groin after treatment, and he was successfully managed with local compression. None of these patients complained of chest congestion or dyspnea after treatment. The time required for thrombus aspiration was 5–11 min (mean 7.7 ± 1.6 min). The time required for the entire procedure (including thrombus aspiration, washing catheter, IVC venography

review, and IVC recanalization) was 40–65 min (mean 50.6 ± 6.5 min). After thrombus aspiration, 12 patients had no visible thrombi on IVC venography, while 5 patients were shown to have the IVC mural thrombi. Afterwards, 13 patients were treated by IVC balloon dilation, and 4 patients were treated by IVC stent insertion. The average IVC pressure decreased from 29.8 ± 3.4 cmH_2O (range 22–35 cmH_2O) to 8.6 ± 2.1 cmH_2O (range 5–11 cmH_2O; $P < 0.001$). Clinical success was achieved in all patients after treatment. BCS-related manifestations improved progressively after treatment.

Follow-up

The average follow-up period was 15.3 ± 11.6 months (range 2–44 months). The 5 patients who had the persistent IVC mural thrombi after thrombus aspiration were shown to have resolution of the thrombus on abdominal ultrasonography during the follow-up. Long-term IVC patency was demonstrated in 15 of 17 (88 %) patients. Two patients experienced the re-obstruction of IVC without thrombosis recurrence at 6 and 8 months after treatment, and were successfully treated with repeat IVC balloon dilation (Table 2). None of the patients experienced chest congestion, dyspnea, or anticoagulation-related bleeding during the follow-up. All patients were alive at the time of this report.

Discussion

This study evaluated the feasibility and effectiveness of combined thrombus aspiration and IVC recanalization in the management of BCS patients with IVC thrombosis. The preliminary results were positive. Technical and clinical successes were achieved in all patients. No patient experienced chest congestion or dyspnea after treatment and during the follow-up.

In Western countries, HV thrombosis continues to be most common in BCS patients [9]; however, IVC obstruction is more common in Asia [9]. Blood flow is slow, and even reversed, thus a thrombus can easily occur in IVC [9]. Zhang et al. [6] and He et al. [10] used catheter direct thrombolysis and oral warfarin to manage 132 and 16 BCS patients with IVC thrombosis before IVC recanalization, respectively; complete resolution of thrombi was achieved in 90 and 88 % patients, respectively. Although no patient experienced bleeding complications during the management of the thrombi in these two studies, the patients still had BCS-related symptoms during the management of the thrombi because the IVC could not be opened before effective management of the thrombi.

IVC thrombi should be cleared rapidly, safely, and effectively in BCS patients. Currently, the mechanical thrombus aspiration device (Aspirex; Straub Medical, Wangs, Switzerland) has been widely used in thrombus clearance instead of thrombolysis [11, 12]. This device consists of a high-speed rotating spiral located in the body of the device that creates negative pressure through an L-shaped aspiration system that can macerate and remove the thrombus [11]; however, use of this device is very expensive. Thrombus aspiration can also be achieved by catheter. Ferrigno et al. [13] used a 6F dual lumen aspiration catheter (AngioJet) to aspirate the thrombus for 16 patients with PE. One lumen carries high-pressure saline that loops back through the distal end into the second lumen, creating a low-pressure vortex that macerates and aspirates the thrombus [13]. Mauri et al. [14] also successfully used a 6F angiographic catheter (Imager II) to aspirate the thrombus for one patient with superior mesenteric vein thrombosis.

In the current study, we used a normal 8F guiding catheter as the aspiration catheter to clear the IVC thrombi. Before the aspiration, we injected the miscible liquids of physiologic saline and urokinase directly to thrombi to loosen the thrombi. Syringe suction was applied manually to the catheter, with the thrombi entrained in the catheter by the extraction strength. In addition, the angled-tip catheter can be better guided for treatment of IVC mural thrombi [12, 15]. Our results demonstrated that 12 of 17 (71 %) patients had no visible thrombi on IVC venography after thrombus aspiration. This rate is comparable to the complete thrombus clearance rate of previous studies regarding thrombus aspiration using 7–9F angled-tip guiding catheters [12, 15]. Although there were 5 patients who had the IVC mural thrombi which could not be aspirated, it was difficult to entirely dislodge the mural thrombus to drop off [9]. In addition, oral warfarin could effectively clear the IVC thrombus after recanalization [9]. Anticoagulation can make the body's natural fibrinolytic system to dissolve the thrombus [9]. Our results also demonstrated that the residual IVC mural thrombi in 5 patients disappeared with oral warfarin during follow-up. Long-term IVC patency following IVC recanalization after thrombus aspiration was 88 %, which is comparable to a previous study regarding IVC recanalization after catheter direct thrombolysis for BCS patients with IVC thrombosis [6].

This study had some limitations. First, the current study was retrospective and the sample size was small. Second, these patients were from a single center. Third, there was no control group in this study.

In conclusion, although further clinical trials are needed, our results demonstrated that combined thrombus aspiration and IVC recanalization can be a safe and effective method for BCS patients with IVC thrombosis. The 8F guiding catheter can be a good choice as the aspiration catheter.

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standards 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.

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

References

1. Cheng D, Xu H, Lu ZJ et al (2013) Clinical features and etiology of Budd–Chiari syndrome in Chinese patients: a single-center study. J Gastroenterol Hepatol 28:1061–1067
2. Gao Y, Chen S, Yu C (2011) Applicability of different endovascular methods for treatment of refractory Budd–Chiari syndrome. Cell Biochem Biophys 61:453–460
3. Han XW, Ding PX, Li YD et al (2007) Retrieval stent filter: treatment of Budd–Chiari syndrome complicated with inferior vena cava thrombosis—initial clinical experience. Ann Thorac Surg 83:655–660
4. Ding PX, Li YD, Han XW, Wu G, Shui SF, Wang YL (2011) Treatment of Budd–Chiari syndrome with urokinase following predilation in patients with old inferior vena cava thrombosis. Radiol Med 116:56–60
5. Ding PX, Li YD, Han XW et al (2010) Agitation thrombolysis for fresh iatrogenic IVC thrombosis in patients with Budd–Chiari syndrome. J Vasc Surg 52:782–784
6. Zhang QQ, Xu H, Zu MH et al (2014) Strategy and long-term outcomes of endovascular treatment for Budd–Chiari syndrome complicated by inferior vena caval thrombosis. Eur J Vasc Endovasc Surg 47:550–557
7. Mood AR (1997) Direct imaging of deep vein thrombosis with magnetic resonance imaging. Lancet 350:1073–1074
8. Leoni CJ, Potter JE, Rosen MP et al (2001) Classifying complications of interventional procedures a survey of practicing radiologists. J Vasc Interv Radiol 12:55–59
9. Sun J, Zhang Q, Xu H et al (2014) Clinical outcomes of warfarin anticoagulation after balloon dilation alone for the treatment of Budd–Chiari syndrome complicated by old inferior vena cava thrombosis. Ann Vasc Surg 28:1862–1868
10. He XH, Li WT, Peng WJ et al (2011) Anticoagulation with warfarin for Budd–Chiari syndrome with chronic inferior vena cava thrombosis: an initial clinical experience. Ann Vasc Surg 25:359–365
11. Eid-Lidt G, Gaspar J, Sandoval J et al (2008) Combined clot fragmentation and aspiration in patients with acute pulmonary embolism. Chest 134:54–60
12. Önder H, Oguzkurt L, Özkan U et al (2013) Endovascular treatment of surgically implanted arterial graft thrombosis by using manual aspiration thrombectomy. Diagn Interv Radiol 19:340–344
13. Ferrigno L, Bloch R, Threlkeld J et al (2011) Management of pulmonary embolism with rheolytic thrombectomy. Can Respir J 18:e52–e58
14. Mauri G, Monti L, Pedicini V (2011) Interventional management of in-stent thrombosis after superior mesenteric vein stenting. EJVES Extra 22:27–29
15. Oğuzkurt L, Ozkan U, Gülcan O et al (2012) Endovascular treatment of acute and subacute iliofemoral deep venous thrombosis by using manual aspiration thrombectomy: long-term results of 139 patients in a single center. Diagn Interv Radiol 18:410–416