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Fracture of inferior vena cava stent after endovascular treatment for Budd-Chiari syndrome: A case series and literature review

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ABSTRACT

Budd-Chiari syndrome (BCS) is a rare condition characterized by hepatic venous outflow obstruction. Balloon angioplasty, with or without stenting, is the recommended first-line treatment modality in Asian countries. As a supplement to balloon angioplasty, expandable metallic Z-stent deployment can effectively improve long-term inferior vena cava (IVC) patency. Although stent placement is a standard and frequently performed treatment, very few IVC stent-related complications, such as stent fractures, have been reported. Here we present a case series and a comprehensive review of IVC stent fractures in patients with BCS. The most common characteristic of IVC stent fractures is a protrusion of the proximal segment of the IVC stent into the right atrium and its systolic and diastolic movements along with heart rhythms. Accurate stent deployment, large-diameter balloon dilation, patient breath-holding training, preferential selection of a triple stent, and the use of an internal jugular vein approach to stent deployment may ensure precise stent localization and avoid postoperative complications.

1. Introduction

Budd-Chiari syndrome (BCS) is a rare vascular condition characterized by hepatic venous outflow obstruction at the level of the hepatic vein (HV) or inferior vena cava (IVC). Percutaneous transluminal balloon angioplasty (PTBA) with or without stenting is the recommended first-line treatment modality in Asian countries. For residual stenosis after the initial angioplasty, recurrent stenosis, and long segmental obstruction of the IVC, stent placement is recommended as a supplement to balloon angioplasty to significantly improve patency.[1,2] Clinically, three main stent-related complications have been sporadically reported: intraoperative stent migration, postoperative in-stent restenosis, and stent fracture. Due to the rarity of BCS and the lack of long-term evaluations of IVC stents, very few IVC stent-related complications, including stent fractures, have been reported. Here we present a case series and a comprehensive literature review of IVC stent fractures in patients with BCS.

2. Case 1

A 58-year-old man with a history of BCS treated with PTBA 13 years prior and IVC stent placement 3 years prior was diagnosed with hepatocellular carcinoma (HCC) at a local hospital during a routine follow-up. Owing to the lack of original documentation and imaging, the IVC obstruction type (membranous or segmental) was unknown. A physical examination revealed signs of chronic liver disease, including splenomegaly without hepatomegaly or ascites. A laboratory evaluation revealed a Child-Pugh score of B-8, normal proteinemia (63.1 g/L), mild hypoalbuminemia (31.4 g/L), thrombocytopenia (40×10^9/L), and an elevated α-fetoprotein level (349.50 ng/mL). Abdominal contrast-enhanced computed tomography (CT) revealed liver cirrhosis, a patent IVC Z-stent (Z-EMS; Yong-Tong, Shenyang, China), moderate splenomegaly, a large spontaneous splenorenal shunt, and a $2.0 \times 2.2 \times 2.4$ cm lesion in the right lobe of the liver.

During transcatheter arterial chemoembolization, an IVC stent fracture was incidentally discovered with a broken Z-loop strut in the proximal segment of the IVC stent. The remaining IVC stent remained intact (Fig. 1). Under fluoroscopic guidance, movement of the proximal

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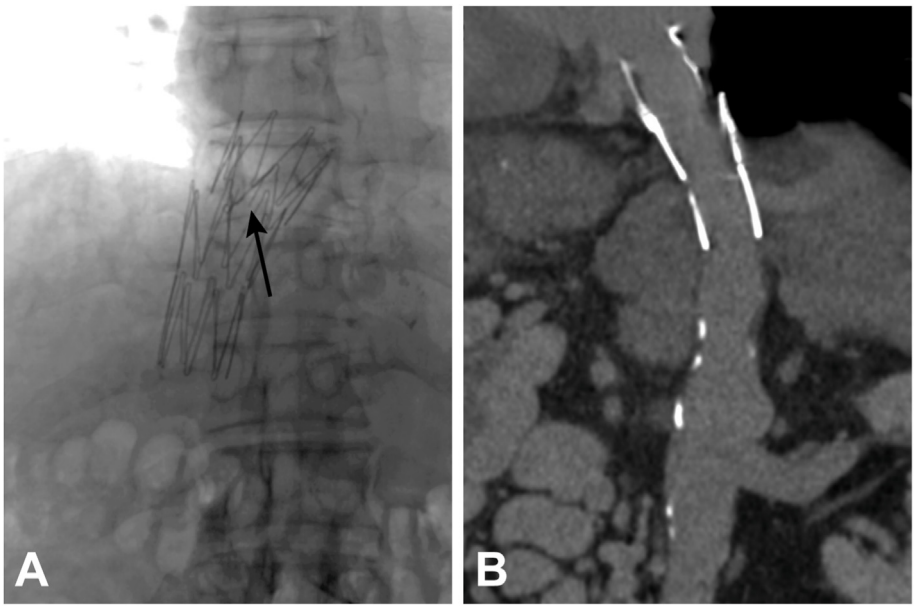

Fig. 1. A 58-year-old man with Budd-Chiari syndrome underwent percutaneous balloon angioplasty 13 years prior and expandable metallic Z-stent placement 3 years earlier. (A) Abdominal X-ray showing one Z-loop strut fracture (arrow) of the proximal segment of the inferior vena cava (IVC) stent. (B) Sagittal computed tomography image showing the proximal segment of the IVC stent partially protruding into the right atrium.

segment of the IVC stent consistent with the heart rhythm was observed. Because of the good patency of the IVC stent and the absence of clinical symptoms or complications such as precardiac tamponade, the fractured IVC stent was not repaired or modified. The patient died 20 months later of HCC. The fractured IVC stent remained unchanged, as confirmed by abdominal CT performed 1 month before his death.

3. Case 2

A 34-year-old man with a history of BCS treated with PTBA and IVC stenting at a local hospital 4 years prior presented with a recurrent abdominal wall portosystemic shunt and a 1-year history of lower-extremity edema. Owing to the lack of original documentation and imaging information, the IVC obstruction type (membranous or segmental) was unknown. At presentation, the patient had normal laboratory parameters. However, chest radiography incidentally showed a fractured Z-loop strut in the proximal segment of the IVC stent, whereas the rest of the IVC stent appeared intact. Abdominal contrast-enhanced CT and duplex ultrasonography revealed a complete in-stent occlusion.

IVC venography via the transfemoral approach was first performed to evaluate the IVC anatomy and obstruction site. Considering the complete IVC occlusion, IVC recanalization was successfully performed using a self-made blunt needle under fluoroscopic guidance. Subsequently, PTBA was performed to restore the IVC diameter with 10- and 18-mm-diameter balloons. Final IVC venography revealed a patent IVC with no complications. Intraoperative fluoroscopy demonstrated that the proximal

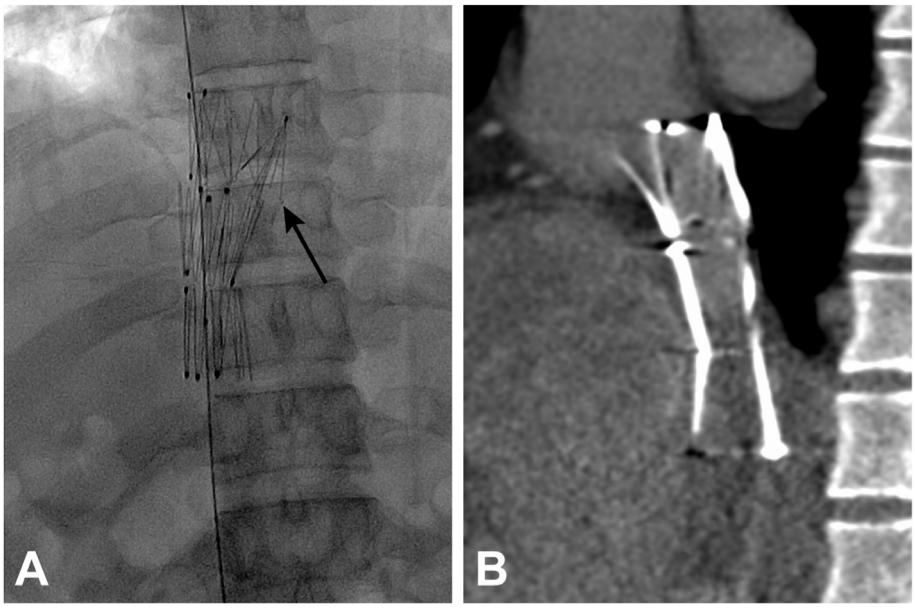

Fig. 2. A 34-year-old man with Budd-Chiari syndrome underwent percutaneous balloon angioplasty and expandable metallic Z-stent placement 4 years prior. (A) Abdominal X-ray showing one Z-loop strut fracture (arrow) of the proximal segment of the inferior vena cava (IVC) stent. (B) Sagittal computed tomography image showing the proximal segment of the IVC stent partially protruding into the right atrium.

segment of the IVC stent moved with the cardiac systolic and diastolic movements (Fig. 2). After the procedure, the patient's symptoms completely resolved within 3 days, and he was discharged.

Five years after the initial recanalization, the patient presented with similar symptoms and imaging findings. Unfortunately, he did not receive any treatment due to financial issues. However, he remained alive 5 years after the first treatment with persistent symptoms.

4. Case 3

A 46-year-old man with BCS treated with PTBA and IVC stenting at a local hospital 12 years prior presented with severe lower-extremity edema for 1 month. Owing to the lack of original documentation and imaging information, the IVC obstruction type (membranous or segmental) was unknown. On admission, chest radiography revealed a fractured and severely deformed proximal segment of the IVC stent with two struts protruding into the lower lobe of the right lung. However, the patient had no clinical symptoms of stent fracture. Abdominal contrast-enhanced CT and duplex ultrasonography revealed in-stent stenosis.

First, IVC venography via the transfemoral approach confirmed in-stent stenosis and stent fractures. Under fluoroscopy, as seen in the previous two cases, the proximal segment of the IVC stent moved cyclically with the heart rhythm. Two broken and migrating struts were observed in the right lower lobe (Fig. 3). Considering IVC stenosis, a guidewire smoothly traversed the obstructed segment with the aid of a Hunter catheter. PTBA was then performed cautiously using a 20-mm-diameter balloon. The final IVC venography revealed a patent IVC. The patient had no procedure-related complications and was discharged uneventfully with complete resolution of the edema.

During the 6-year-long follow-up, the patient had no recurrent symptoms of BCS or complications due to stent fracture.

5. Discussion

IVC stent fracture is a rare postoperative complication of the endovascular treatment of BCS. Although rare, it can lead to severe complications and death. Here we report the largest collection of IVC stent fracture cases, present a comprehensive review of the reported cases of IVC stent fractures in patients with BCS (Table 1), summarize the reasons for IVC stent fracture, and suggest a method to avoid this complication.

The expandable metallic Z-stent is composed of stainless-steel wires (diameter, 0.45 mm) that are bent to form “Z” shapes and then welded to form a cylinder. Two of these cylindrical segments were connected to two struts. Compared to the Gianturco stent made by Cook Medical, there are no fixation barbs to prevent migration. Double- and triple-segment stents are available. A single segmental stent is unavailable due to its excessive unintentional anterior jump during deployment.[3] Only the expandable metallic Z-stent is recommended by the Chinese Society of Interventional Radiology for the endovascular treatment of BCS for the following reasons: (1) its availability in large-diameter sizes to fit the IVC; (2) sufficient radial force; (3) wide interstices between the stent wires to preserve HV orifice patency; and (4) predictable stent length compressed or expanded.[3,4] However, the main disadvantage of the stent is its characteristic “anterior jump” migration upon deployment. This is likely why the proximal segment of the stent easily enters the right atrium during deployment. Additionally, from an anatomical perspective, the shape of the cavoatrial junction resembles a funnel, which increases the risk of anterior slippage. Hence, IVC stents are at risk of migrating into the right atrium.

In the English literature, there is only one case report of an IVC stent fracture after BCS. Lin et al.[5] reported a case of IVC stent fracture in a 42-year-old man with BCS treated with an IVC stent 3 years prior. Fragments of the fractured IVC stent were found in the IVC, right atrium, left pulmonary artery, and right HV, causing a right atrial–aortic fistula and atrial septal perforation. Emergency open-heart surgery was performed to repair multiple heart injuries and remove the fractured fragments from the right heart chambers.

We identified three additional cases of IVC stent fractures in the Chinese literature. Wang et al.[6] reported a case of a 59-year-old woman with BCS. A 10-year-old IVC stent was identified as fractured, with the proximal segment stent located at the cavoatrial junction. Fractured fragments were found in the right atrium, tricuspid valve, ventricular septum, right ventricular free wall, and left lower lobe lateral segment that caused a right atrial–aortic fistula. Cardiac surgery was performed to remove the fractured fragments of the IVC stent from the right heart chamber and repair the right atrial–aortic fistula. Li et al.[7] reported a case of a 56-year-old man with BCS. An 11-year-old IVC stent was fractured, and fragments were found traversing the right ventricular wall, causing

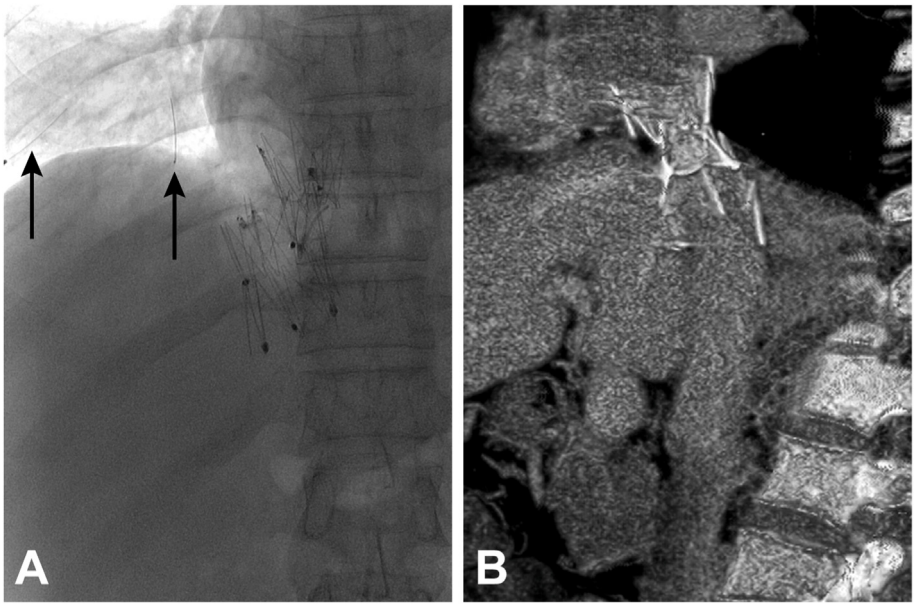

Fig. 3. A 46-year-old man with Budd-Chiari syndrome underwent percutaneous balloon angioplasty and expandable metallic Z-stent placement 12 years earlier. (A) Abdominal X-ray showing severe fracture and deformation of the proximal segment of the inferior vena cava (IVC) stent and two fragments in the inferior lobe of the right lung (arrow). (B) Sagittal computed tomography image showing the proximal segment of the IVC stent partially protruding into the right atrium.

Table 1
Characteristics of study participants.

Ref.	Age (years)/ Sex	Stent type	Protruding into right atrium (Yes/No)	Stent placement duration (years)	IVC status	Fragment site	Stent fracture complications	Stent fracture management	Follow-up time (months)	Patient status
Case 1	58/M	Triple	Yes	3	Patency	In situ	No	No	20	Deceased
Case 2	34/M	Triple	Yes	4	Restenosis	In situ	No	No	60	Alive
Case 3	46/M	Triple	Yes	12	Restenosis	RA, LPA	No	No	72	Alive
Lin et al., 2013	42/M	–	Yes	3	N/A	IVC, RA, LPA, RHV	Multiple heart injuries	Cardiac surgical repair	N/A	N/A
Wang et al., 2015	59/F	Triple	Yes	10	N/A	IVC, RA, TV, VS, RVFW, LPA	Right atrial–aortic fistula	Cardiac surgical repair	N/A	N/A
Li et al., 2007	56/M	–	Yes	11	N/A	VS, RVW	Pericardial tamponade	Cardiac surgical repair	2	Alive
Hou et al., 2016	45/M	Triple	Yes	9	Patency	In stent	No	Interventional removal	N/A	N/A

IVC = inferior vena cava; RA = right atrium; TV = tricuspid valve; VS = ventricular septum; RVFW = right ventricular free wall; LPA = left pulmonary artery.

pericardial tamponade. Emergency open-heart surgery was performed to remove the fractured fragments and repair the ruptured right ventricular walls. Finally, Hou et al.[8] reported the case of a 45-year-old woman with BCS. A 9-year-old IVC stent was identified as fractured during an angiographic assessment; the rest of the IVC stent was intact, and a fractured IVC stent strut was found in the IVC. The strut was removed using an Amplatz goose neck snare kit via transfemoral access.

There was one common characteristic among the four previously reported cases and our three cases of IVC stent fracture: protrusion of the proximal segment of the IVC stent into the right atrium of varying lengths. We previously reported that none of the 40 expandable metallic IVC Z-stents of the 37 patients protruded into the right atrium, and no stent fracture occurred during the mean follow-up of 61.89 ± 41.45 (range, 1–125) months.[3] As a supplement, we measured the distance from the proximal stent to the right atrium on these patients' intraoperative digital subtraction angiography images. The mean distance was 10.05 ± 8.90 (range, 0–31) mm. Fluoroscopy after stent deployment demonstrated slightly normal cardiac systolic, diastolic, and respiratory movements of the IVC stent. Based on these clinical assessments, we determined that the IVC stent fracture mainly occurred due to protrusion of the stent into the right atrium, which caused metal fatigue and long-term stress due to cardiac systolic and diastolic movements. When a stent fracture occurs, fragments of the stent can separate from the main body and migrate distally to the right atrium, tricuspid valve, ventricular septum, right ventricular free wall, pulmonary artery, and distal branches. These fragments can damage structures or organs, resulting in serious complications.

Based on our experience, to ensure the precise deployment of the expandable metallic Z-stent and prevent it from protruding into the right atrium, the following should be considered: (1) the stent should be located within 2–5 mm on the upper edge of the obstructed segment; (2) pre-dilation of the obstructed IVC using a large balloon should match the IVC diameter and stent diameter to decrease the anterior jump strength of the IVC stent (e.g., a 25-30-mm-diameter stent is deployed after pre-dilation with a 25-30-mm-diameter balloon); (3) the patient's cooperation and good breath during the procedure can minimize the anterior pulling force produced by large breathing movements; (4) a triple stent is preferentially selected because it is more stable than a double stent and can guarantee that the HV orifices remain uncovered; and (5) adopting the internal jugular vein approach to deploy the IVC stent, which could effectively avoid stent forward migration into the right atrium. However, this stent deployment approach may increase the risk of downward migration.

In conclusion, IVC stent fracture is rare after stent deployment in patients with BCS and IVC obstruction. However, it can lead to severe complications. IVC stent protrusion into the right atrium is the main cause of IVC stent fracture, which can be reasonably and safely managed using several key procedural steps to avoid complications.

Ethical approval

The study was approved by the ethics committee of The First Affiliated Hospital of Zhengzhou University. All clinical practices and observations were conducted in accordance with the Declaration of Helsinki.

Patient consent

Written informed consent was obtained from patients for publication of these case reports and any accompanying images.

Declaration of competing interest

The authors of this manuscript declare no relationship with any companies, whose products or services may be related to the subject matter of the article.

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