Cardiovasc Intervent Radiol (2011) 34:615–619
DOI 10.1007/s00270-010-0009-6

TECHNICAL NOTE

Repositioning of Covered Stents: The Grip Technique

John Martin Kirby · Xiao Feng Guo · Mehran Midia

Received: 27 April 2010 / Accepted: 20 September 2010 / Published online: 5 November 2010

Abstract
Introduction Retrieval and repositioning of a stent deployed beyond its intended target region may be a difficult technical challenge.
Materials and Methods A balloon-mounted snare technique, a variant of the coaxial loop snare technique, is described.
Results The technique is described for the repositioning of a covered transjugular intrahepatic portosystemic shunt stent and a covered biliary stent.
Conclusion The balloon-mounted snare technique is a useful technique for retrieval of migrated stents.

Keywords Foreign body retrieval · Transjugular intrahepatic portosystemic shunt (TIPS/TIPSS) · Biliary stent

Introduction

Many devices and techniques have been developed to manipulate misplaced or malpositioned objects, including the loop snare, basket, grasping forceps, tip-deflecting wire, pincher device, and oversized catheter or sheath [1–6]. Among these, the loop snare technique is the most commonly used, mainly as a result of its high success rate, relatively low cost, and few procedure-related complications [7–9]. Unintentional stent deployment in a nontarget region is a serious complication for interventional radiologists. Retrieving a stent deployed beyond its intended target region may be a difficult technical challenge. We describe two cases in which we successfully repositioned a fully deployed stent by use of a balloon-mounted snare technique, a variant of the loop snare technique.

J. M. Kirby (✉) · M. Midia
McMaster University Medical Center, 1200 Main Street West, Hamilton, ON L8N 3Z5, Canada
e-mail: johnkirby@ireland.com

X. F. Guo
McGill University, Montreal, QC, Canada

Case 1

A 71-year-old woman was referred for an elective transjugular intrahepatic portosystemic shunt (TIPS) procedure to decompress the portal system before surgery for a recently diagnosed rectal cancer. She had known alcohol-induced liver disease and had previously undergone esophageal variceal banding. Ascites and a predominantly right-sided pleural effusion had been documented on prior imaging. She was not clinically encephalopathic, and biochemistry indicated Child-Pugh class B status. The initial stages of the procedure were uneventful. Access into the right portal vein was obtained using the modified Ross transseptal needle. A 4F measuring pigtail catheter was advanced into the superior mesenteric vein and the portosystemic pressure gradient (PSPG) calculated at 34 mmHg.

The transhepatic tract was dilated with a 5F, 8-mm-diameter, 4-cm-long angioplasty balloon (Blue Max, Boston Scientific, MA, USA). After withdrawal of the balloon catheter, a 12F delivery sheath was placed, and a 6/2 Viatorr (Gore, Flagstaff, AZ, USA) stent was deployed in satisfactory position (Fig. 1A). Following stent deployment, the PSPG could not be accurately measured through the 5F multipurpose angled catheter as a result of tenting against the vein wall. PSPG calculated through the 4F pigtail was 21 mmHg. It was decided to advance the delivery sheath

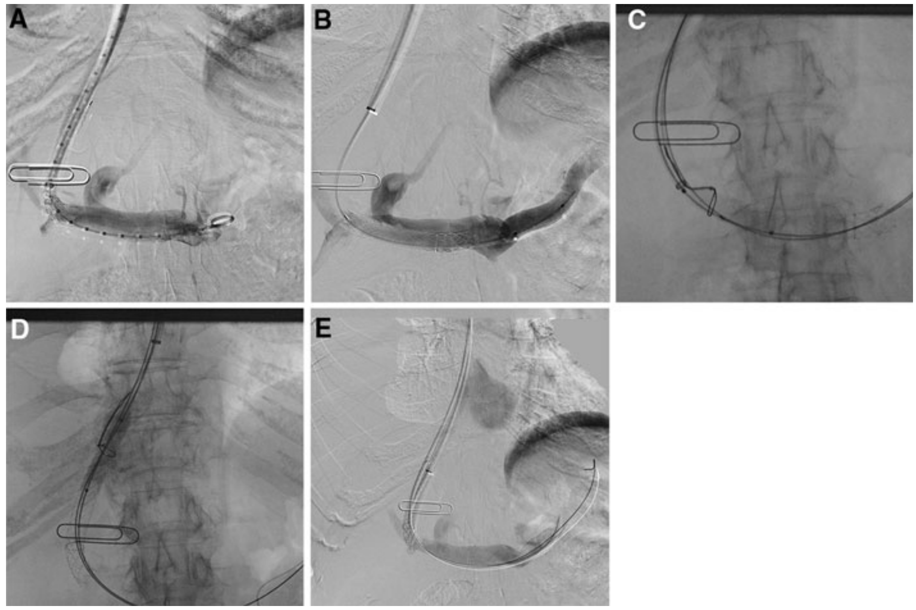

Fig. 1 **A** The 6/2 Viatorr stent is initially deployed into satisfactory position. **B** The stent graft is inadvertently dislodged distally into the portal confluence. **C** The balloon is inflated across the proximal end of the stent, facilitating snare placement. **D** The whole system has been slowly withdrawn into the parenchymal track. **E** The balloon has been deflated and the snare removed. Venography shows satisfactory position

through the stent, first to allow pullback (over-the-wire) sidearm portal pressure to be measured across the stent, and second to facilitate possible balloon dilation and variceal embolization.

During over-the-wire manipulation of the delivery sheath, with its dilator in situ, the stent graft was inadvertently dislodged distally into the portal confluence (Fig. 1B). The stent was pulled back over a hand-inflated 10-mm-diameter, 4-cm-angioplasty balloon into the main portal vein, but it remained fully deployed below the TIPS tract. Heparin (2,000 units) was given intravenously.

Placement of an additional stent was regarded as a poor option because of the potential for the covered portion to compromise portal perfusion. Snaring the stent with a 15-mm 5F Amplatz GooseNeck snare (ev3, Plymouth, MN, USA) from both proximal and distal ends was unsuccessful. At any rate, we were concerned that even had we been able to snare the stent, it may have been impossible to pull it back into the parenchymal tract without damaging either the stent or the tract.

Therefore, we placed the snare over a 10-mm, 4-cm balloon and advanced both together into the sheath, inflating the balloon across the proximal end of the stent. This allowed easier placement of the snare over the balloon and onto the proximal stent (Fig. 1C). Once secured, the entire unit was pulled back into the tract, with the balloon redilating the track akin to a bougie (Fig. 1D). Once satisfactory position had been achieved, the balloon was deflated and the snare removed. Check angiographic appearance was satisfactory (Fig. 1E), although the portosystemic gradient remained elevated at 19 mmHg (down from 34 mmHg). Coil embolization of the largest esophageal varices was performed.

Although the final pressure gradient was not satisfactory, we were reluctant to proceed immediately with further manipulation, either with balloon dilation or with additional stent placement, because of concerns regarding further migration, and the fact that the proximal end seemed to be in a satisfactory position. No further intervention was performed at that time. Follow-up ultrasound at 1 week and catheter venography after 6 weeks were entirely satisfactory, with a measured portosystemic gradient of 5 mmHg, and the patient's ascites resolved.

Case 2

A 52-year-old man with a low common bile duct stricture was referred for insertion of a retrievable covered metallic stent. Six weeks before, he had presented with jaundice, and after unsuccessful endoscopic retrograde cholangiopancreatography, he had had a percutaneous internal–external biliary drain placed, with several subsequent episodes of catheter leakage. He had a history of chronic and necrotizing pancreatitis and abdominal abscess, and he had previously undergone successful stent insertion for portal vein occlusion. Serial imaging had shown no evidence of evolving mass, and a benign biliary stricture was presumed.

The initial stages of the procedure were uneventful. A nitinol, self-expanding, silicone-covered, 80 × 8 mm biliary stent (Tae-Woong Medical, Korea) was introduced over an Amplatz guide wire after removal of the internal/external drain. The lower end of the delivery system was placed into the duodenum, with the stricture at the mid-portion of the stent. The deployment mechanism involved distal unsheathing; however, for unknown reasons, the

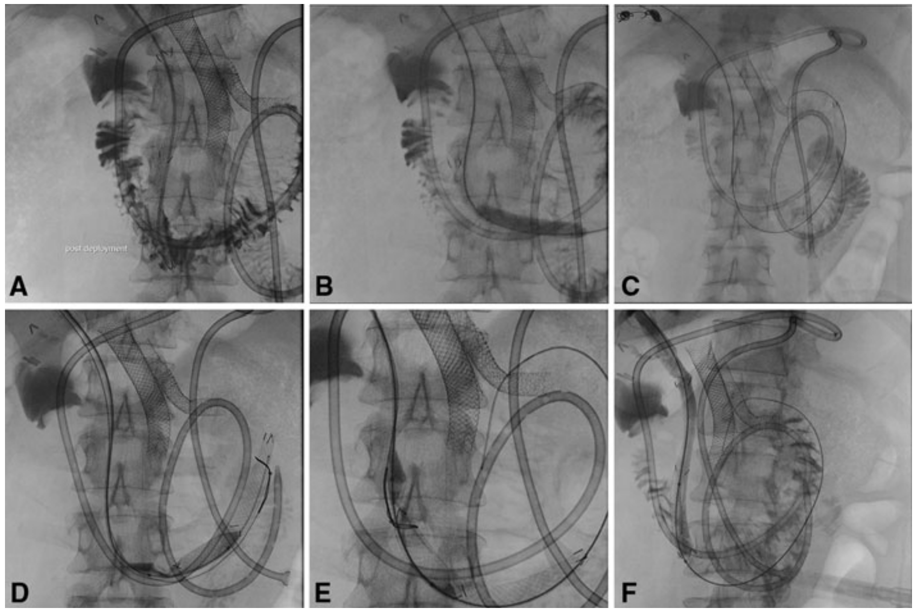

Fig. 2 **A** The lower end of the fully deployed biliary stent remains unopened. **B** Fluorostore imaging during balloon dilation of the distal stent demonstrates forward migration. **C** The stent is now fully deployed in the duodenum. **D** A 15-mm snare, introduced alongside an 8-mm over-the-wire balloon, has been looped over the still-closed lower end of the stent. **E** The opened snare loop has been manipulated to the upper end of the stent and the partly inflated balloon gripped. **F** Both balloon and stent have been withdrawn into the common bile duct to satisfactory position. The distal stent has been opened with the balloon

lower end of the stent did not open on sheath withdrawal. Attempts at opening the distal end by resheathing and unsheathing were unsuccessful. Eventually the stent was fully deployed proximally in the hope that the distal end would later open completely. However, the lower end remained unopened (Fig. 2A), and a decision was made to open the stent with a balloon. An 8 mm × 4 cm balloon was placed over an Amplatz guide wire and inflated across the distal end of the stent (Fig. 2B). Unfortunately, this caused inadvertent forward stent migration through the stricture into the duodenum (Fig. 2C).

A 15-mm Amplatz GooseNeck snare (ev3, Plymouth, MN, USA) was then introduced, looped over the deflated balloon. However, the snare could not be deployed over the proximal flared end of the deployed stent, even with partial inflation of the balloon. Ultimately, the snare was placed beyond the stent, with the loop passed over the still-closed distal end (Fig. 2D), and gradually manipulated toward the proximal end. With the balloon inflated, the snare was tightened and stent, balloon, and snare were pulled back into the common bile duct (Fig. 2E). The lower end of the stent was then opened using the balloon (Fig. 2F).

Discussion

Stents are widely used for managing vascular, biliary, bronchial, urinary, and gastrointestinal obstruction. Several cases of stent migration during transjugular TIPS procedures have been reported [10–15], and manufacturer guidelines for safe insertion of the Viatorr endoprosthesis indicate that once the uncovered portion is opened in the portal vein, the stent cannot be retrieved. Stent migration involving the biliary tree [16] and the cardiovascular system [17] has also been described.

Repositioning of misplaced stents may be difficult as a result of several factors, including size and rigidity. Fully deployed stents are much more challenging to retrieve than incompletely or unopened stents, particularly when beyond an area of stenosis, and care must be taken not to compound the problem by damaging, buckling, or kinking the stent.

Many devices have been used to retrieve intravascular objects—snares, grasping forceps, baskets, tip-deflecting wires, pincher devices, oversheaths, and balloon catheters [5, 7, 18, 19]. Although retrieval baskets have proved useful in foreign body manipulation [1], they cannot be guided and are thus difficult to manipulate, particularly in large vessels such as the vena cava [14]. The use of grasping forceps for foreign body manipulation has been reported [4, 20], but usage has been limited as a result of traumatic events caused by their large size and rigid construction. The loop snare has been the primary choice because in most cases it is highly effective, easy to use, and results in few complications [7–9, 21]. Various snaring techniques have been described [14, 21–23]. One potential limitation for the snaring technique is that a free end of the foreign body must be available. Moulin et al. describe percutaneous retrieval of a distally dislodged Strecker stent that had slipped off its angioplasty balloon [24]. A loop snare was used to retrieve the proximal end while the stent was stretched via a multipurpose basket catheter attached to the distal end from a femoral approach, to facilitate resheathing. Taylor et al. described several different strategies for management of superior vena cava stents migrated into the right atrium, including three approaches involving the use of snares [25]. In one case, a migrated

Luminex nitinol stent was directly snared from the femoral vein and deployed in the common iliac vein. In another case, a loop snare passed alongside the exterior of a Wallstent was used to capture a guide wire passed through the stent, and the guide wire/stent/snare combination was then withdrawn and removed through a femoral sheath. Finally, and similar to the technique we describe, a snare was positioned over an angioplasty balloon inflated within the stent, allowing relocation.

The balloon-mounted snare technique, as used in our cases, is a variant of coaxial loop snare technique. Seong et al. illustrated the utility and advantages of such a technique for the retrieval of tubular foreign bodies in seven patients, including two stents [14]. A guide wire within the lumen of the malpositioned stent facilitates loop placement because the angle between the snare axis and the stent is minimized [14]. The use of a balloon at the proximal end of the stent not only facilitates the placement of the loop around the leading margin, further eliminating the angle between the snare axis and stent for safe and smooth extraction without injury to the access route [14], but also greatly increases the grip strength, which is essential for manipulating an already fully deployed stent. Repositioning of the stent is further facilitated by the balloon redilating the tract or stricture, akin to a bougie, during withdrawal. In addition, the balloon supports the inside of the fully deployed stent frame, reducing the risk of damage or buckling due to tight snare loop.

This was the only case of covered stent misplacement we have encountered since we switched to using the Viatorr device almost exclusively in 2006. A number of potential causes are considered. First, had balloon dilation of the deployed stent been performed before attempted sheath replacement, the endoprosthesis may have been more securely anchored within the parenchymal tract.

Second, while manufacturer guidelines for the Viatorr stent graft caution against reintroduction of either introducer sheath or working catheter back through the endoprosthesis so as not to displace a deployed stent, such manipulation may be required to allow concomitant variceal embolization at the time of TIPS placement. Embolization through the working catheter alone (with the guiding sheath in the hepatic vein or inferior vena cava), can be challenging. We have preferred a 12F introducer sheath (over the recommended 10F) because of the ease of stent advancement and improved stability across the right atrium. It is unclear whether embolization should be performed before tract angioplasty and stent placement, performed routinely after TIPS, or reserved for certain anatomic subsets, such as gastric varices, patients with previous bleeding, or persistently increased PSPG [26], or to reduce the risk of chronic hepatic encephalopathy in large shunts by improving hepatic portal perfusion.

For the second case, the decision to balloon open the distal end could be questioned. It would not have been unreasonable to maintain percutaneous access and follow up with a plain radiograph after 24 h to see whether the (self-expanding) stent had fully opened. Nonetheless, we think that the failure to open may have been a technical issue, possibly related to the retrieval suture, and we elected to intervene, thinking that we could solve the issue quickly and remove the internal–external drain. The resistance to forward migration for covered stents, even those with flanged proximal ends, is far less than that for uncovered stents.

The balloon-mounted snare technique could be used for repositioning of both covered and uncovered stents in the vascular, biliary, urinary, or enteric systems. Retrieval of uncovered stents might be expected to be more challenging compared to covered stents as a result of the greater friction across the bare interstices. However, for the same reason, migration/dislodgement of uncovered stents is uncommon. In practice, unless an arterial stent fully deployed distal to a stenosis is covering a critical branch, placement of an additional stent is usually an appropriate, albeit expensive, solution that avoids the potential for additional trauma/spasm that can occur with placement of a snare/manipulation. Covered stents in general are more resistant to infolding and tend to retain their shape because of the additional tensile effect of the covering component. As with most retrieval techniques, the potential for damage is greatest at the end of the stent, typically well away from any leak or fistula, which is typically at the center of the stent. As such, any fraying of the covering fabric should remain confined to the end only. Damage to the struts is uncommon if there is wire access through the stent such that the snare tightens in an even, circumferential manner.

In summary, we describe two cases in which fully deployed covered stents were successfully repositioned with a balloon-mounted snare technique, a variant of the loop snare technique.

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

References

1. Egglin TK, Dickey KW, Rosenblatt M, Pollak JS (1995) Retrieval of intravascular foreign bodies: experience in 32 cases. AJR Am J Roentgenol 164:1259–1264
2. Dotter CT, Rosch J, Bilbao MK (1971) Transluminal extraction of catheter and guide fragments from the heart and great vessels; 29 collected cases. Am J Roentgenol Radium Ther Nucl Med 111:467–472
3. Morse SS, Strauss EB, Hashim SW et al (1986) Percutaneous retrieval of an unusually large, nonopaque intravascular foreign body. AJR Am J Roentgenol 146:863–864

4. Selby JB, Tegtmeyer CJ, Bittner GM (1990) Experience with new retrieval forceps for foreign body removal in the vascular, urinary, and biliary systems. Radiology 176:535–538
5. Nemcek AA Jr, Vogelzang RL (1987) Modified use of the tip-deflecting wire in manipulation of foreign bodies. AJR Am J Roentgenol 149:777–779
6. Katske FA, Celis P (1991) Technique for removal of migrated double-J ureteral stent. Urology 37:579
7. Cekirge S, Weiss JP, Foster RG et al (1993) Percutaneous retrieval of foreign bodies: experience with the nitinol goose neck snare. J Vasc Interv Radiol 4:805–810
8. Koseoglu K, Parildar M, Oran I, Memis A (2004) Retrieval of intravascular foreign bodies with goose neck snare. Eur J Radiol 49:281–285
9. Wolf F, Schernthaner RE, Dirisamer A et al (2008) Endovascular management of lost or misplaced intravascular objects: experiences of 12 years. Cardiovasc Interv Radiol 31:563–568
10. Cekirge S, Foster RG, Weiss JP, McLean GK (1993) Percutaneous removal of an embolized Wallstent during a transjugular intrahepatic portosystemic shunt procedure. J Vasc Interv Radiol 4:559–560
11. Cohen GS, Ball DS (1993) Delayed Wallstent migration after a transjugular intrahepatic portosystemic shunt procedure: relocation with a loop snare. J Vasc Interv Radiol 4:561–563
12. Ferguson E, Cwikiel W (2006) Percutaneous removal of two self-expanding stent grafts following failed deployment. Acta Radiol 47:667–671
13. Sanchez RB, Roberts AC, Valji K et al (1992) Wallstent misplaced during transjugular placement of an intrahepatic portosystemic shunt: retrieval with a loop snare. AJR Am J Roentgenol 159:129–130
14. Seong CK, Kim YJ, Chung JW et al (2002) Tubular foreign body or stent: safe retrieval or repositioning using the coaxial snare technique. Korean J Radiol 3:30–37
15. Zemel G, Katzen BT, Becker GJ et al (1991) Percutaneous transjugular portosystemic shunt. JAMA 266:390–393
16. Abramson AF, Javit DJ, Mitty HA et al (1992) Wallstent migration following deployment in right and left bile ducts. J Vasc Interv Radiol 3:463–465
17. Foster-Smith KW, Garratt KN, Higano ST, Holmes DR Jr (1993) Retrieval techniques for managing flexible intracoronary stent misplacement. Cathet Cardiovasc Diagn 30:63–68
18. Gabelmann A, Kramer S, Gorich J (2001) Percutaneous retrieval of lost or misplaced intravascular objects. AJR Am J Roentgenol 176:1509–1513
19. Dondelinger RF, Lepoutre B, Kurdziel JC (1991) Percutaneous vascular foreign body retrieval: experience of an 11-year period. Eur J Radiol 12:4–10
20. Millan VG (1978) Retrieval of intravascular foreign bodies using a modified bronchoscopic forceps. Radiology 129:587–589
21. Savader SJ, Brodkin J, Osterman FA Jr (1996) In situ formation of a loop snare for retrieval of a foreign body without a free end. Cardiovasc Interv Radiol 19:298–301
22. Curry JL (1969) Recovery of detached intravascular catheter or guide wire fragments. A proposed method. Am J Roentgenol Radium Ther Nucl Med 105:894–896
23. Park JH, Yoon DY, Han JK et al (1992) Retrieval of intravascular foreign bodies with the snare and catheter capture technique. J Vasc Interv Radiol 3:581–582
24. Moulin G, Andre P, Chagnaud C et al (1995) Percutaneous retrieval of a Strecker stent misplaced during TIPS. Cardiovasc Interv Radiol 18:337–339
25. Taylor JD, Lehmann ED, Belli AM et al (2007) Strategies for the management of SVC stent migration into the right atrium. Cardiovasc Interv Radiol 30:1003–1009
26. Tesdal IK, Filser T, Weiss C et al (2005) Transjugular intrahepatic portosystemic shunts: adjunctive embolotherapy of gastroesophageal collateral vessels in the prevention of variceal rebleeding. Radiology 236:360–367