Jpn J Radiol (2011) 29:286–290
DOI 10.1007/s11604-010-0540-z

TECHNICAL NOTE

Microcoil embolization during abdominal vascular interventions through microcatheters with a tip of 2 French or less

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Received: September 5, 2010 / Accepted: November 1, 2010

Abstract
Purpose. The aim of this study was to evaluate the technical aspects of embolization using microcoils through a microcatheter with a tip of 2F or smaller during abdominal vascular interventions.
Materials and methods. Coil embolization through a microcatheter with a tip of 2F or smaller was attempted in 73 procedures. Two types of microcoil—Liquid Coil (Boston Scientific, Watertown, MA, USA) and Tornado Coil (Cook, Bloomington, IN, USA)—were deployed through four types of thinner microcatheter [2F tip (n = 49) and 1.8F tip (n = 24)]. Coil jams in the microcatheter and coil migration were evaluated.
Results. In total, 286 microcoils were placed (mean ± SD, 3.9 ± 4.3 coils per procedure, range 1–32 coils). In 19 procedures (26.9%), Liquid Coils were used alone. In 44 (60.3%), Tornado Coils were used alone. In 10 (13.7%), Liquid Coils and Tornado Coils were combined. There were no coil jams in the microcatheter in this series. One Tornado Coil (0.3%) delivered into the gastroduodenal artery migrated to the right hepatic artery.
Conclusion. Liquid Coils and Tornado Coils can be placed through a thinner microcatheter without difficulty. However, there is a risk of coil migration in large vessels or at the proximal site because the catheter tip is not stabilized.

Key words Microcoil · Embolotherapy · Thinner microcatheter

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Introduction

Coil embolization is frequently necessary during abdominal vascular interventions, such as for hemostasis of peritoneal or gastrointestinal bleeding[1] and prevention of nontarget embolization accompanied by transcatheter arterial chemoembolization (TACE) for hepatocellular carcinoma (HCC).[2] With advances in microcatheter technologies, superselective catheterization even into small branches has become possible.[3] A thinner microcatheter can only be accessed when the target vessel is small and tortuous; therefore, coil deployment through a thinner microcatheter is required in some circumstances. However, coil deployment through a microcatheter with a tip of 2F or smaller cannot be ensured because of the narrow inner lumen. In addition, there is a risk of misplacement of the microcoil due to sagging of the catheter tip because the tip of a thinner microcatheter is highly flexible.

We attempted coil embolization during abdominal vascular interventions using microcatheters with a tip of 2F or smaller. We describe our experience here.

Materials and methods

We performed a retrospective study to analyze the technical aspects of microcoil embolization through a thinner microcatheter during abdominal vascular interventional procedures. Institutional review board approval is not required for this type of study at our institution. Written informed consent was obtained from each patient before the interventional procedure.

Between January 2003 and May 2010, coil embolization through a microcatheter with a tip of 2F or less was attempted in 73 abdominal vascular interventional procedures in 61 patients. We attempted microcoil embolization through thinner microcatheters in two types of case: (1) cases in which TACE for HCC was simultaneously attempted ($n = 49$); and (2) cases in which catheterization into the target branch seemed difficult because it was small and tortuous ($n = 12$).

There were 35 men and 26 women with a mean ± SD age of 68.4 ± 10.2 years (range 33–84 years). In all, 12 procedures were performed for hemostasis of gastrointestinal bleeding ($n = 10$) or intraperitoneal bleeding ($n = 2$), and gastric or colonic branches were mainly embolized. A total of 41 procedures were attempted to occlude small branches that did not supply the liver, such as the falciform artery or gastric branches, during TACE for HCC to prevent nontarget embolization. Another 20 procedures were attempted to occlude arterioportal shunts of the liver. Among them, 19 procedures were performed before TACE for HCC to prevent massive inflow of embolic materials into the portal veins through preexisting arterioportal shunts. The remaining procedure was performed to occlude a high-flow arterioportal shunt that developed after percutaneous transhepatic obliteration of rectal varices. Hepatic arterial branches were embolized by microcoils during the procedures.

Four types of microcatheter with a tip of 2F or less were used. Among 73 procedures, Progreat α (Terumo, Tokyo, Japan) with a 2F tip was used in 48 procedures, Carnelian Pixie (Tokai Medical Products, Kasugai, Japan) with a 1.8F tip was used in 19, Carry Win (UTM, Nagoya, Japan) with a 1.8F tip was used in 5, and Masters Parkway (Asahi Intecc, Seto, Japan) with a 2F tip was used in 1.

Two types of microcoil were used: Berenstein Liquid Coils (Boston Scientific, Watertown, MA, USA) and Tornado Embolization Microcoils (Cook, Bloomington, IN, USA). The Liquid Coils were delivered by saline infusion using a 2.5-ml syringe. The Tornado Coils were delivered by a pusher wire. A 0.016-inch guidewire (GT-wire; Terumo) was used as the pusher wire in all but six procedures. In the remaining six procedures, a 0.017-inch pusher wire (C-Stopper; Piolax, Kanagawa, Japan) was used. Coil type and size were determined according to the configuration of the target branch and its arterial flow. The Liquid Coils were mainly used for tortuous branches. With the Tornado Coils, the coils were slightly larger than the diameter of the target branch, in particular when the blood flow of the target branch was fast. Coil jams in the microcatheter and coil migration were evaluated.

Results

In all, 88 arterial branches were embolized during 73 procedures (Table 1). A total of 286 microcoils (79 Liquid Coils and 207 Tornado Coils; mean 3.9 ± 4.3 coils per procedure, range 1–32 coils) were delivered through thinner microcatheters. In 19 procedures (26.9%), 1–8 (mean 2.5 ± 1.5) Liquid Coils were used alone. In 44 procedures (60.3%), 1–32 (mean 4.2 ± 1.5) Tornado Coils were used alone. In 10 procedures (13.7%), 1–8 (mean 3.1 ± 2.3) Liquid Coils and 1–6 (mean 2.4 ± 1.8) Tornado Coils were combined. The 5–20 cm long Liquid Coils were deployed through a thinner microcatheter. For Tornado Coils, 2 × 3 mm to 2 × 5 mm diameter coils were used.

There were no coil jams in the microcatheter during any procedure in this series. All but one of the target branches were successfully embolized by microcoils through thinner microcatheters (Fig. 1). Of 286 microcoils, one 2 × 3 mm diameter Tornado Coil (0.3%) delivered into the gastroduodenal artery through the Masters Parkway catheter migrated to the right hepatic artery during coil deployment. In this case, microcoil embolization of the gastroduodenal artery had already been performed in another hospital to stop bleeding from pancreatic carcinoma (one microcoil had already

Table 1. Embolized arterial branches

Embolized branch	No.
Hepatic artery (distal to the subsubsegmental artery)	21
Left gastric artery	11
Falciform artery	8
Right gastric artery	7
Accessory left gastric artery	7
Right inferior phrenic artery	7
Right colic artery	6
Gastroduodenal artery	4
Posterosuperior pancreaticoduodenal artery	3
Ileal artery	3
Anterosuperior pancreaticoduodenal artery	2
Omental artery	2
Posterior intercostal artery	2
Cystic artery	1
Dorsal pancreatic artery	1
Left internal mammary artery	1
Transverse pancreatic artery	1
Right renal artery (arcuate artery)	1
Total	88

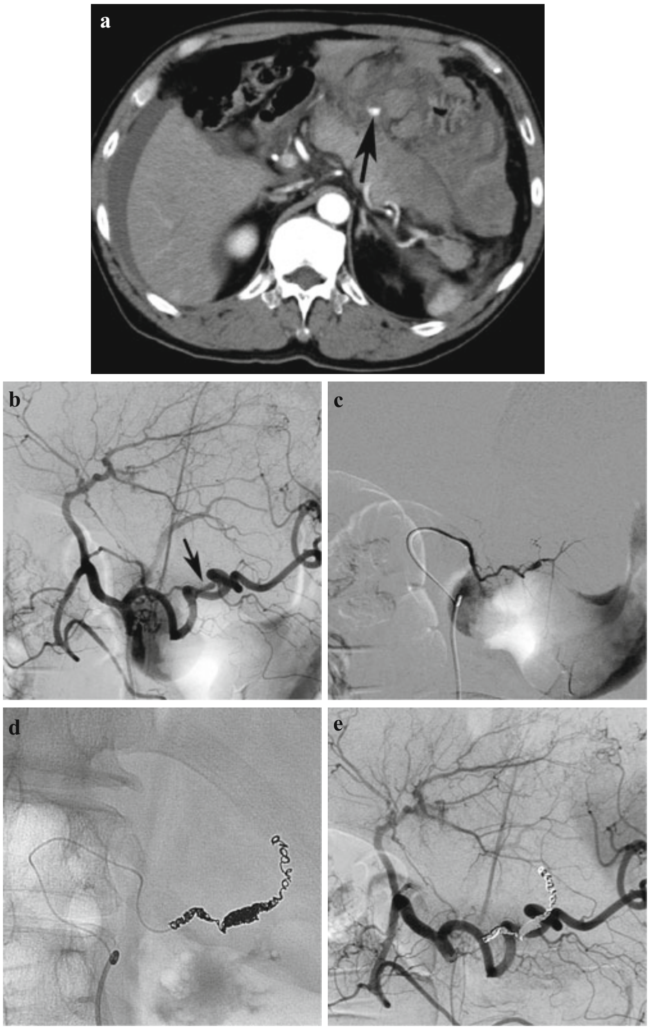

Fig. 1. A 54-year-old man had spontaneous rupture of the right gastric artery. **a** Arterial phase computed tomography (CT) shows intraperitoneal hemorrhage and extravasation of contrast material from the right gastric artery (*arrow*). **b** Celiac arteriography shows the tortuous right gastric artery with aneurysmal dilatation (*arrow*). **c** Arteriography of the right gastric artery raises a suspicion of segmental arterial mediolysis. **d** Right gastric artery was embolized using 32 Tornado Coils through a 1.8F tip microcatheter. **e** Celiac arteriography after microcoil embolization shows occlusion of the right gastric artery. Hemostasis was obtained with the procedure

migrated into the right hepatic artery), and additional coil embolization of the gastroduodenal artery stump was attempted because of recurrent bleeding. After coil migration, the microcatheter was exchanged for a 2.2F tip Progreat β^3 microcatheter (Terumo), and coil embolization of the gastroduodenal stump was performed using a 5 cm long Liquid Coil. The distal part of the Liquid Coil also partially migrated into the right hepatic artery. Subsequently, the dorsal pancreatic artery derived from the superior mesenteric artery was embolized using Liquid Coils though a Masters Parkway microcatheter. The bleeding stopped after the procedure (Fig. 2).

Discussion

Microcoils are widely used for arterial embolization, and they are effective for localized and permanent vascular occlusion.[1,2,4–6] Several microcoil designs have been developed and used for abdominal vascular interventional procedures.[4–6] Coil embolization for gastrointestinal bleeding and traumatic vascular lesions is an alternative to surgery.[1]

A thinner microcatheter has an advantage over a conventional microcatheter for highly selective catheterization,[3] and it is mainly used for TACE for HCCs. Combined use of coil embolization during the procedure makes it possible to perform effective TACE through unselectable tumor-feeding branches.[2] In addition, coil embolization of nonhepatic branches originating from the hepatic arteries or arterioportal shunts in the tumor-bearing area may reduce the adverse effects of TACE. Coil embolization is frequently necessary during TACE for HCC. However, coil deployment is not accepted by most thinner microcatheters because of the narrow inner lumens. Therefore, another microcatheter with a wider lumen is required to perform microcoil embolization. If microcoils can be deployed through thinner microcatheters, it may reduce the cost. In addition, treatment outcomes may become safer and more effective when embolization is performed as selectively as possible. To keep the embolized vessels to a minimum, the ischemic tissue damage in the embolized vascular territory may be reduced. From such viewpoints, we proposed to deploy microcoils through thinner microcatheters.

According to the instructions on how to use the Tornado Coil, the coils are recommended for use through microcatheters that accept 0.018-inch maximum diameter guidewires. In the present study, we used four types of microcatheter with a tip of 2F or less. According to product information for each of these thinner microcatheters, one microcatheter (Masters Parkway) can accept only a 0.018-inch guidewire. Two microcatheters (Progreat α and Carnelian Pixie) accept a 0.016-inch guidewire, and one microcatheter (Carry Win) accepts only a 0.014-inch guidewire. The minimal inner diameter of each microcatheter is 0.017-inch (Carnelian Pixie and Carry Win), 0.019-inch (Progreat α), and 0.022-inch (Masters Parkway), respectively. However, our personal experience is that a 0.017-inch pusher wire can be passed through a microcatheter (Carry Win) that accepts a 0.014-inch guidewire. We speculate that the true inner

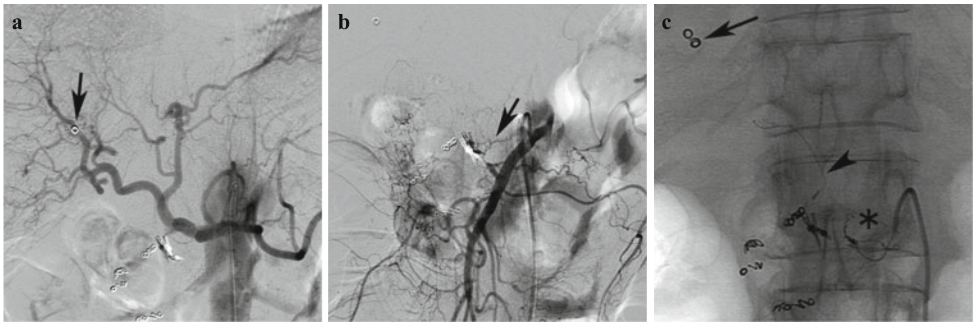

Fig. 2. A 59-year-old woman had recurrent bleeding from pancreatic carcinoma after coil embolization. **a** Celiac arteriography shows that the gastroduodenal artery had been embolized by microcoils at another hospital. The migrated coil in the right hepatic artery was also seen (*arrow*). **b** Superior mesenteric arteriography shows the patent dorsal pancreatic artery (*arrow*). **c** One Tornado Coil was delivered into the gastroduodenal artery stump through a 2F tip microcatheter, but it migrated into the right hepatic artery (*arrow*). The microcatheter was exchanged for a 2.2F tip microcatheter, and one 5 cm long Liquid Coil was delivered. The distal part of the Liquid Coil partially migrated into the right hepatic artery (*arrowhead*). Subsequently, the dorsal pancreatic artery was embolized using two Liquid Coils through a 2F tip microcatheter (*asterisk*). Hemostasis was successful and was maintained until the patient's death 3 months later

diameter of each thin microcatheter may be wider than that described in the specifications.

Both the Liquid Coils and Tornado Coils could be deployed through all four types of thinner microcatheter, and there were no coil jams in the catheter during any procedure in this series. In one case, 32 Tornado Coils were deployed through a microcatheter that accepted only a 0.014-inch guidewire without difficulty. Our results indicated that thinner microcatheters had a sufficient lumen to deploy Liquid Coils and Tornado Coils. In addition, a 0.016-inch GT-wire could be used as a pusher-wire to deliver the Tornado Coils. We believe that superselective coil embolization through a thinner microcatheter may improve the technical success and expand the indications for abdominal vascular interventional procedures as well as reduce the cost.

Coil migration occurred with one Tornado Coil (0.3%) deployed into the gastroduodenal artery stump. In this case, two causes of coil migration were speculated. First, the gastroduodenal artery stump was too short to place the Tornado Coil. Second, the microcatheter tip was too flexible and could not be stabilized because it was not deeply advanced into the gastroduodenal artery. In such a case, we do not recommend the use of a thinner microcatheter to deploy the microcoils. Detachable microcoils may be safe and effective, although they are expensive and a special microcatheter is required.

There are several limitations in this study. First, we used only two types of microcoil. Our results did not support the passage of other types. In an experimental study by Tajima et al.,[7] other types of microcoils [Hilal (Cook), Micronester (Cook), Vortex (Boston Scientific), and C-Stopper Coil (Piolax)] could be passed through a 2F tip microcatheter (Meister Cath Superselective Plus; Medikit, Tokyo, Japan) using a saline-flush technique. However, we have never deployed microcoils other than Liquid Coils and Tornado Coils through a thinner microcatheter. Second, all Tornado Coils were deployed using a wire-push technique; a saline-flush technique was not attempted. Because the tip of a thinner microcatheter is highly flexible, the microcatheter tip may become dislodged if the saline-flush technique is used to deploy the Tornado Coils. Third, all coil embolization procedures were performed when the microcatheters were advanced into small target vessels. We do not recommend coil embolization through a thinner microcatheter in large vessels or at the proximal site because the catheter tip is not stabilized. Conventional microcatheters should be used when microcoil placement is attempted in the proximal portion of a large vessel. Fourth, the Liquid Coil has been discontinued and is no longer available, so currently we only use Tornado Coils. Finally, the trial of coil embolization through a thinner microcatheter should be performed with the personal responsibility of each interventional radiologist.

Conclusion

Liquid Coils and Tornado Coils can be placed through a microcatheter with a tip of 2F or less without difficulty. The catheter tip may not become dislodged during coil deployment when coil embolization is performed at the distal level. However, we do not recommend coil embolization through a thinner microcatheter in large vessels or at proximal sites because the catheter tip is not stabilized.

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