Clinical Usefulness of the Triaxial System in Emergency Transarterial Embolization with N-butyl-2-cyanoacrylate: A Report of Two Cases

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Abstract
We report two cases of acute arterial hemorrhage successfully treated by transarterial embolization, using the triaxial system and n-butyl-2-cyanoacrylate (NBCA). Case 1 is a 78-year-old man with a large hematoma in the rectus abdominis muscle. Case 2 is a 63-year-old man with massive jejunal bleeding and shock. In both cases, severe coagulopathy was present, and safe embolization with NBCA was necessary. In the triaxial system, which consists of a 1.9-French (F) microcatheter, a 2.7-F high-flow microcatheter, and a 4-F catheter, the high-flow microcatheter introduced through the 4-F catheter usually acts as supporting catheter to advance the 1.9-F microcatheter distally. In our cases, the high-flow microcatheter was also useful for the prevention of NBCA reflux into an untargeted artery, and thus, safe embolization could be performed.

Key words: triaxial system, coaxial system, N-butyl-2-cyanoacrylate (NBCA), transarterial embolization

Introduction
N-Butyl-2-cyanoacrylate (NBCA; Histoacryl; B. Braun, Tuttlingen, Germany), which allows rapid and permanent embolization with fast polymerization when it comes into contact with blood, has several advantages compared with other embolic materials, including gelatin sponge, metallic coils, and polyvinyl alcohol [1-6]. However, NBCA reflux can cause undesirable and excessive embolization [1]. When the corresponding bleeding vessels originate from the superior mesenteric artery (SMA) or external iliac artery (EIA), acute bowel or lower limb ischemia may occur. Thus, combination with coil embolization is sometimes necessary to prevent NBCA reflux [3, 4].

The triaxial system, also called the triple coaxial or double coaxial system, consists of a 4-French (F) catheter, a 2.7-F high-flow microcatheter, and a 1.9-F microcatheter, which is designed to be used coaxially with a high-flow microcatheter (Fig. 1). This system provides enhanced accessibility to small or tortuous target vessels by offering a strong backup. Additionally, in the event of adhesion of NBCA to the tip of the 1.9-F microcatheter, the 2.7-F microcatheter can act as a defensive wall and prevent NBCA reflux into other branches. If the 2.7-F microcatheter is advanced into a safe portion apart from an untargeted artery, safe embolization can be performed.

Here, we report two cases in which emergency transarterial NBCA embolization was safely performed using the triaxial system.

Case Reports

Case 1
A 78-year-old man, who was hospitalized for the treat-
ment of interstitial pneumonia, developed sudden and severe abdominal pain. Contrast-enhanced computed tomography (CT) revealed a large hematoma mainly located in the rectus abdominis muscle, and there was extravasation of contrast agent within the hematoma, which indicated active bleeding (Fig. 2a). Coagulopathy (international normalized ratio, 3.24) due to oral administration of warfarin for atrial fibrillation and severe cough caused by the interstitial pneumonia were the possible reasons for his abdominal wall hematoma. Emergency transarterial embolization was performed. The right femoral artery was punctured and a 4-F catheter (Cobra; Terumo Clinical Supply, Gifu, Japan) was advanced into the left EIA, using a crossover approach. Selective angiography of the left inferior epigastric artery demonstrated extravasation of the contrast agent (Fig. 2b). Embolization with NBCA was thought to be necessary because of his severe coagulopathy. However, the left inferior epigastric artery was narrow and tortuous, making it difficult to advance the 4-F catheter into the inferior epigastric artery. If NBCA adherence to the microcatheter tip occurred during the embolization procedure with a conventional system, removal of the microcatheter may cause NBCA reflux into the EIA, which may lead to embolic limb ischemia. Thus, the triaxial system was applied to prevent NBCA reflux. In this system, a 150-cm 1.9-F microcatheter (Carnelian MARVEL Non-Taper; Tokai Medical Products, Aichi, Japan), a 110-cm 2.7-F distal, 2.9-F proximal high-flow microcatheter (Sniper 2 high-flow; Terumo, Tokyo, Japan), and a 0.014-inch, 180-cm microguidewire (Chikai; Asahi Intec, Nagoya, Japan) were used. Both the 2.7-F high-flow and 1.9-F microcatheters were advanced into the left inferior epigastric artery (Fig. 2c). NBCA mixed with Lipiodol (LPD; Guerbet, Villepinte, France) at a ratio of 1:3 was injected through the 1.9-F microcatheter (total injected volume, 0.6 mL). Neither NBCA reflux nor NBCA adhesion at the 1.9-F microcatheter tip occurred in this case. Angiography of the left inferior epigastric artery from the 2.7-F microcatheter after embolization demonstrated extravasation of the contrast agent (Fig. 2d). Subsequent angiography of the left EIA also demonstrated favorable blood flow to the left lower limb.

Case 2

A 63-year-old man was admitted to our hospital because of massive gastrointestinal bleeding and shock. He had undergone pancreatectoduodenectomy for pancreatic cancer 6 months earlier. Extravasation within the jejunal lumen was noted on contrast-enhanced CT. Laboratory tests showed the following results owing to massive bleeding: hemoglobin, 7.1 g/dL; platelet, 2000/μL; serum albumin, 1.99 g/dL; prothrombin time, 58%. The endovascular procedure was approached via the right femoral artery with a 4-F sheath, and the SMA was selected with a 4-F shepherd’s hook catheter (Terumo, Tokyo, Japan). Selective angiography of the first jejunal branch showed extravasation within the jejunal lumen (Fig. 3a). Safe and precise embolization without NBCA reflux was necessary because NBCA reflux in other branches of the SMA may cause bowel ischemia or necrosis. Thus, the triaxial system, using the same devices as in case 1, was applied to perform safe and accurate embolization with NBCA. A 2.7-F high-flow microcatheter was inserted into the first jejunal branch, and a 1.9-F microcatheter was advanced further near the bleeding point (Fig. 3b). With this position, even if NBCA reflux caused by adhesion to the 1.9-F microcatheter tip occurred when removed, the 2.7-F microcatheter may serve as a protective wall to prevent NBCA reflux into other branches. The NBCA-LPD mixture, at a ratio of 1:2, was injected from the 1.9-F microcatheter (total injected volume, 0.4 mL), and subsequently, the 1.9-F microcatheter was quickly removed. A small mass of NBCA adhered to the tip of a 1.9-F microcatheter, but it was safely detached by the 2.7-F microcatheter, and overflow into an untargeted jejunal branch was prevented. Angiography after embolization showed the selective embolization of the bleeding artery (Fig. 3c). No major complication such as bowel necrosis occurred; however, 12 days later, he passed away due to progression of multiple organ failure.

Discussion

The triaxial system consists of a 4-F catheter, a 2.7-F microcatheter, and a 1.9-F microcatheter (Fig. 1). The 4-F catheter with 0.038-inch inner diameter is necessary for this...
Figure 2. (a) Contrast-enhanced computed tomography reveals a large hematoma in the abdominal rectus muscle. There is extravasation (arrow) within the hematoma, which indicated active bleeding. (b) Emergency angiography of the left inferior epigastric artery shows leakage of contrast agent (arrow). (c) The triaxial system. The 4-F catheter was placed in the left EIA, and the 2.7-F high-flow microcatheter was in the left inferior epigastric artery (white arrow), which strongly supported the 1.9-F microcatheter and provided stability and safety of embolization procedure. The 1.9-F nontapered microcatheter was inserted into the high-flow microcatheter, and its tip (black arrow) was more distal than that of the 2.7-F microcatheter. (d) Angiography of the left inferior epigastric artery after injection of the N-butyl-2-cyanoacrylate–Lipiodol mixture showed complete embolization of the bleeding vessel.

The 1.9-F microcatheter is nontapered and can be inserted into a 2.7-F microcatheter, which has a 0.027-inch inner diameter [7, 8]. The inner diameter of the 1.9-F innermost catheter is 0.0165 inches because of its nontapered shape; thus, 0.014-inch microguidewires or 0.012-inch compatible coils can be passed through. The 2.7-F microcatheter gives a more stable position for the advancement of the 1.9-F nontapered microcatheter into the bleeding artery. In addition, by inserting the 1.9-F nontapered microcatheter, the gap between the 2.7-F microcatheter and microguidewire becomes smaller; thus, the 2.7-F microcatheter can be inserted more distally along the 1.9-F nontapered microcatheter and microguidewire. Therefore, the 1.9-F nontapered microcatheter can be inserted much more distally, with effective backup provided by the 2.7-F microcatheter in the triaxial system. Because of advantages described above, this system is also used for non-emergent situations such as type 2 endoleak embolization after endovascular aortic repair and super-selective transcatheter arterial chemoembolization for hepatocellular carcinoma [7, 8]. As of 2016, the triaxial system using other devices is also available.

With the conventional coaxial system, if NBCA adheres to the microcatheter tip, NBCA may reflux to the point where the 4-F catheter is placed, which may lead to undesirable and excessive embolization. Meanwhile, with the triaxial system, if NBCA adheres to the 1.9-F microcatheter tip, it comes off when the 1.9-F microcatheter is removed into the 2.7-F microcatheter, and the NBCA reflux is blocked at the point where the 2.7-F microcatheter is placed. Therefore, the embolized area can be predicted based on the positions of the 1.9- and 2.7-F microcatheters, leading to safe embolization. However, the tip of the 2.7-F high-flow microcatheter might be occluded by detached NBCA casts when the 1.9-F microcatheter accompanying NBCA casts is with-
Cannulae within the access route [7].

Thus, NBCA should not be excessively overflowed beyond the 1.9-F nontapered microcatheter tip.

Another advantage of using this system is that it allows us to exchange the 1.9-F innermost microcatheter through the 2.7-F microcatheter easily [7]. Even if the first embolization using NBCA-LPD cannot stop active bleeding, the exchange of the 1.9-F microcatheter enables subsequent embolization quickly. Furthermore, when using the conventional coaxial system, repeated superselective catheterization into the responsible artery is required for the additional injection of NBCA-LPD, which is sometimes difficult and requires prolonged procedure time. However, with this triaxial technique, repeated superselective catheterization with the 1.9-F innermost microcatheter can be performed more easily and rapidly through the 2.7-F support microcatheter, which remains within the access route [7].

However, this technique has several disadvantages. First, it costs more than the conventional technique. Second, it is more time consuming. Preparing and advancing two catheters during an emergency situation take time. Although this technique may have clinical promise, further studies should be performed to decide its indication in emergency transarterial embolization.

In conclusion, we reported two cases in which the triaxial system facilitated safe embolization by using NBCA-LPD. This modified transarterial technique may be useful for the prevention of NBCA-LPD reflux.

**Conflict of interest:** The authors declare that they have no conflicts of interest to report.

**References**


**Figure 3.** Post-pancreatoduodenectomy state. (a) Selective arteriogram of the first jejunal branch originating from the superior mesenteric artery (SMA) shows extravasation of the contrast agent (arrow) within the jejunal lumen. (b) The triaxial system. The tip of the 1.9-F microcatheter (black arrow) was advanced near the bleeding point. The 2.7-F high-flow microcatheter was also inserted into the bleeding artery (white arrow), which strongly backed up the 1.9-F microcatheter and also served as a protective wall to prevent N-butyl-2-cyanoacrylate (NBCA) reflux into other branches of the SMA. Manual injection of contrast agent revealed persistent extravasation (arrowhead). (c) Angiography after injection of the NBCA-Lipiodol mixture shows selective embolization of the bleeding artery (arrow).