—Case Reports—

Glue in Lockdown Technique to Embolize Peripheral Arterial Aneurysms

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As a blood flow control technique for embolization using glue (*n*-butyl cyanoacrylate; NBCA) for peripheral artery aneurysm/pseudoaneurysm, we placed a vascular plug or coils at the proximal inflow vessel before glue injection. We describe this maneuver, which we call the glue in lockdown technique. Four peripheral aneurysms—two pulmonary artery pseudoaneurysms, one pancreaticoduodenal arcade pseudoaneurysm, and one internal iliac artery aneurysm—deemed unsuitable for conventional embolization because of abnormal blood flow, coagulopathy, or anatomical complexity were embolized with our technique. Technical and clinical outcomes were reviewed to evaluate the effectiveness of the procedure. Reliable and rapid embolization was achieved in coagulopathy cases and hemodynamically or anatomically complicated lesions. Glue in lockdown technique was successfully used to treat peripheral aneurysms and can be further developed for application to other lesions.
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Key words: NBCA, *n*-butyl cyanoacrylate, peripheral artery aneurysm

Introduction

Glue (*n*-butyl cyanoacrylate; NBCA) has been used as a liquid embolization material in endovascular embolization for various vascular disorders[1–3]; however, inappropriate glue distribution can cause unexpected organ damage[4,5]. In contrast, metallic embolization materials such as coils and vascular plugs come in various sizes and offer flexibility to suit the vascular anatomy; however, the thrombosing capability of metallic materials is uncertain, especially in coagulopathic conditions[6]. Glue and metallic materials can offset their respective disadvantages and have been used together[6–9]. Before glue embolization of peripheral pseudo or true aneurysms, simultaneous blood outflow alteration and inflow control are required. Blood outflow alteration refers to embolization to inhibit antegrade blood flow into outflow vessels such as the side branches arising from the aneurysmal wall. Adequate inflow control during glue injection can avoid organ damage caused by unexpected migration of glue under native blood flow. To semi-occlude the inflow vessel we developed a technique that involves the initial use of metallic materials, followed by filling of the aneurysm and/or outflow vessels. This report illustrates the technical elements of this procedure, named the glue in lockdown technique.

Materials and Methods

Glue in Lockdown Technique

During glue injection via a microcatheter advanced into the aneurysm or outflow vessel, the inflow feeding vessel is first partially occluded (i.e., some blood continues to flow after occlusion) with metallic materials, which we refer to as the glue in lockdown technique. The early phase after deployment of a vascular plug or loosely placed coils ensures semi-occlusion of the inflow vessel. When using a vascular plug (**Fig. 1a**), the microcatheter used for glue injection is preloaded and penetrates the vascular plug (Amplazer Vascular Plug, AVP; Abbot Cardiovascular, Minneapolis, MN, USA), as previously reported[10]. When using coils (**Fig. 1b**), two micro-

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catheters are advanced in parallel distally for glue injection and proximally for coil placement. The mixture ratio of the glue (Histoacryl; B. Braun, Melsungen, Germany) and iodized oil (Lipiodol; Guerbet, Aulnay-sous-Bois, France) is unified to 33%. When evaluating technical outcome, we require simultaneous closure of outflow and inflow; filling of the aneurysmal sac with glue is not essential. Spontaneous thrombosis within the sac is expected after elimination of the exits for blood.

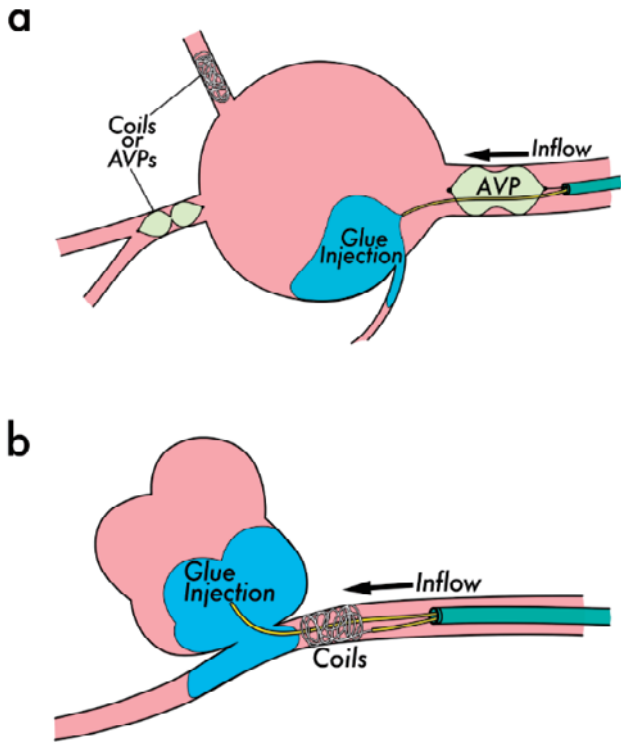

Fig. 1 Illustration of the glue in the lockdown technique. The outflow vessels are first embolized, if possible, and an AVP (Amplatzer Vascular Plug) or coils are placed in the inflow vessel before glue injection. When using the AVP (a), glue is injected via a microcatheter preloaded through the AVP. When using coils (b), two microcatheters are advanced distally in parallel for glue injection and proximally for coil placement.

Patient Characteristics

Between December 2020 and May 2021, the glue in lockdown technique was used for four patients (age range, 80-87 years; median age, 81.5 years; **Table 1**) with peripheral vascular aneurysms. Two pulmonary artery pseudoaneurysms (Case 1, 2), one pseudoaneurysm at the pancreaticoduodenal arcade (Case 3), and one true left internal iliac artery (IIA) aneurysm (Case 4) were treated. All patients underwent clinical follow-up for 2-7 (median 4) months post-procedure to evaluate residual flow in the aneurysms. Written informed consent was obtained from all patients or their families.

Assessment

Technical and clinical outcomes were reviewed to assess the efficacy of the procedure. Technical success was defined as complete angiographic occlusion of the aneurysm. Clinical success was defined as cessation of growth or regression of the aneurysm within 30 days after the procedure[11].

Results

Technical Outcome

Case 1: An 80-year-old man with aspergillosis who had undergone transcatheter arterial embolization of systemic arteries, including the right bronchial, intercostal, internal mammary, and other branches of the right subclavian arteries, using glue and coils presented with massive hemoptysis due to a 20-mm pseudoaneurysm at the proximal right upper pulmonary artery (**Fig. 2a**). Blood flow in the right upper lobe was completely reversed by multiple shunts between the systemic arteries (**Fig. 2b**). First, two vascular plugs (8 mm of AVP 4 and AVP II) were deployed to the two branches distal to the pseudoaneurysm. Second, a vascular plug (16 mm of AVP) was deployed to the orifice of the upper lobe branch. Thereafter,

Table 1 Patient characteristics and embolization data

Case No.	Age (y)/ sex	Symptom	Diagnosis	Underlying disease	Coagulopathy	Metallic materials	Glue ratio (%)	Outcome
1	80/M	Hemoptysis	Pulmonary artery PA	Aspergillosis	No	AVP	33	Efficient
2	87/M	Hemoptysis	Pulmonary artery PA	PTE	Yes	Coil	33	Efficient
3	82/M	Anemia	PA of pancreaticoduodenal arcade	CI	Yes	Coil	33	Efficient
4	81/M	None	Left IIA aneurysm	Arteriosclerosis	No	AVP	33	Efficient

PA; Pseudoaneurysm, IIA; Internal iliac artery, PTE; Pulmonary thromboembolism, CI; Cerebral infarction, AVP; Amplatzer vascular plug

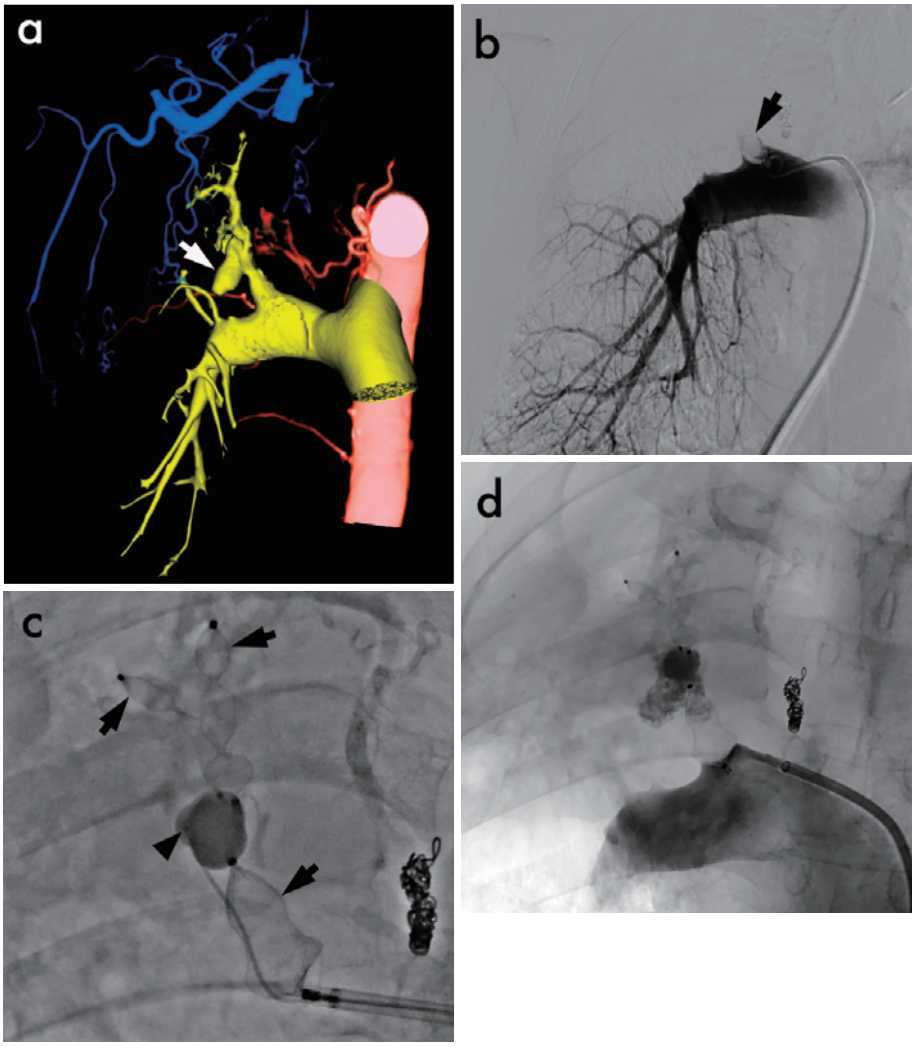

Fig. 2 An 80-year-old man with aspergillosis (Case 1).
A 3D-CT scan (a) shows a pseudoaneurysm at the right upper lobe pulmonary artery (arrow). Right pulmonary artery angiography (b) shows reversed blood flow within the upper lobe artery (arrow) from multiple shunts between the systemic arteries. Three vascular plugs are placed at two distal branches of the pseudoaneurysm and the orifice of the upper lobe artery (c, arrows), and glue is injected via the microcatheter preloaded through the AVP (c, arrowhead) until the pseudoaneurysm is completely filled (d).

1.5 mL of 33% glue was slowly injected via a microcatheter (Carnelian SI; Tokai Medical Products, Kasugai, Japan) that was preloaded through the AVP and advanced into the pseudoaneurysm (**Fig. 2c**). The microcatheter was removed after filling the pseudoaneurysm with glue (**Fig. 2d**).

Case 2: An 87-year-old man presented with massive hemoptysis from the right upper lobe bronchus at the rate of 2 L/h immediately after surgical thrombectomy for pulmonary arterial thromboembolism. Emergency angiography revealed the source of bleeding to be a pseudoaneurysm at the peripheral branch of the P3 segment (**Fig. 3a**). Two microcatheters (Carnelian Marvel NT; Tokai Medical Products) were advanced in parallel into the distal and the proximal parts of the pseudoaneurysm via a 6-Fr guiding catheter (Mach 1; Boston Scientific, Marlborough, MA, USA). Two coils (Target XL; Stryker Neurovascular, Fremont, CA, USA) were placed via the proximal catheter, and 0.6 mL of 33% glue was then injected via the distal catheter until the pseudoaneurysm was filled (**Fig. 3b**).

Case 3: An 82-year-old man on anticoagulant therapy because of acute cerebral infarction had a pseudoaneurysm at the bifurcation of the anterior and posterior superior pancreaticoduodenal arteries (ASPDA and PSPDA, **Fig. 4a**). Two microcatheters (Carnelian Marvel NT) were inserted into a 4.5-Fr guiding catheter (ParentPlus45, I-Simmons; Medikit, Tokyo, Japan) via the superior mesen-

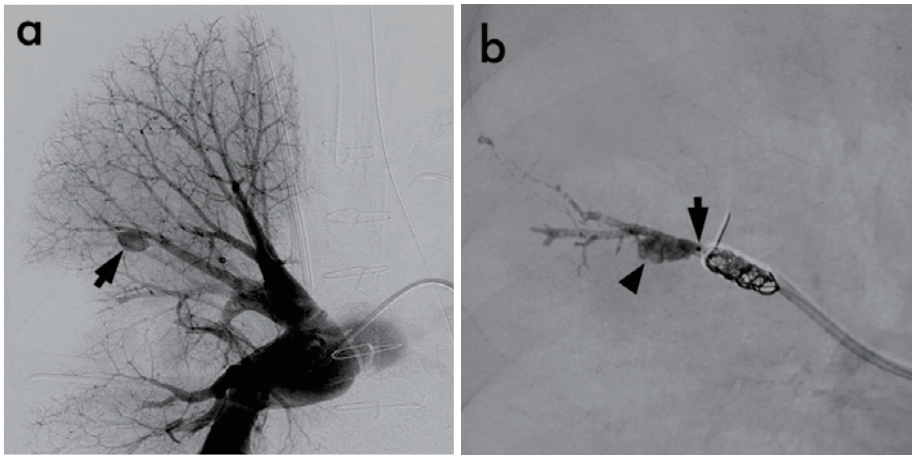

Fig. 3 An 87-year-old woman after surgical thrombectomy for pulmonary thromboembolism (Case 2).
Right pulmonary artery angiography (a) shows a pseudoaneurysm at the peripheral branch of the P3 segment (arrow). After coils are placed at the proximal part, glue is injected via the microcatheter (b, arrow) until the peripheral branch and pseudoaneurysm (b, arrowhead) are filled.

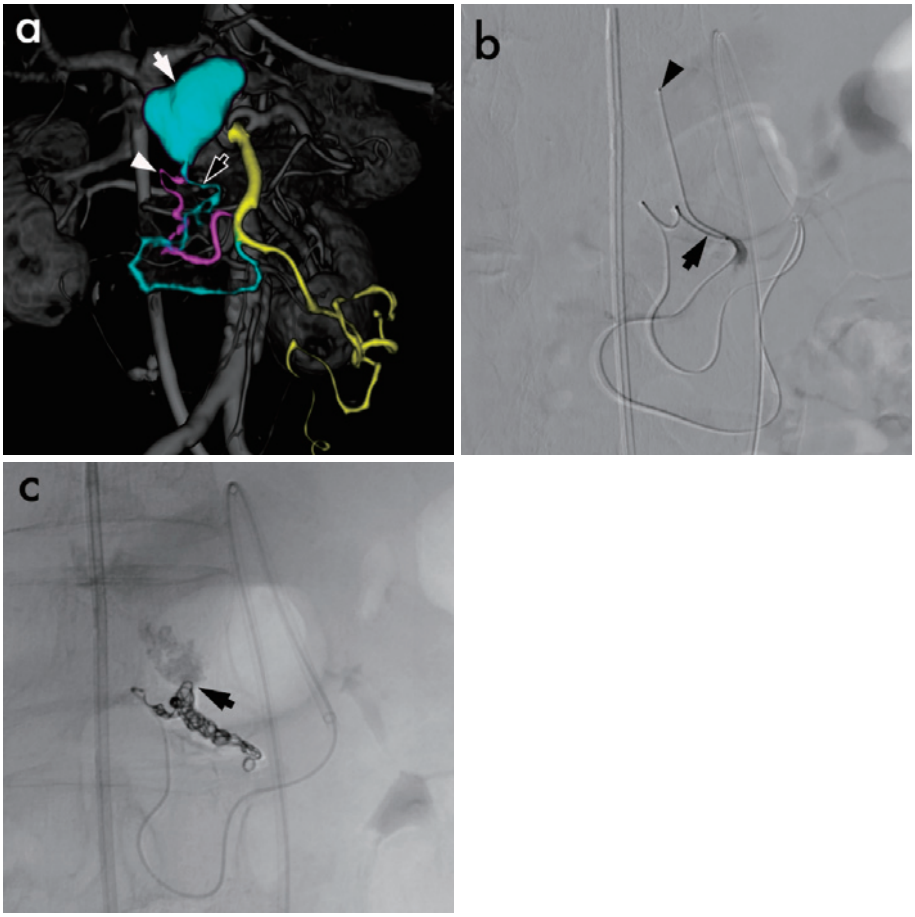

Fig. 4 An 82-year-old man with retroperitoneal hemorrhage (Case 3).
A 3D-CT scan shows a pseudoaneurysm (a, white arrow) at the bifurcation of the ASPDA (a, black arrow) and PSPDA (a, arrowhead). Using the guiding catheter placed in the SMA, one microcatheter was navigated through the PSPDA and advanced into the ASPDA (b, arrow) and another was navigated through the ASPDA into the pseudoaneurysm (b, arrowhead). The neck of the pseudoaneurysm (c, arrow) is filled with glue after the coils are placed at the segment from the ASPDA to the PSPDA across the rupture site.

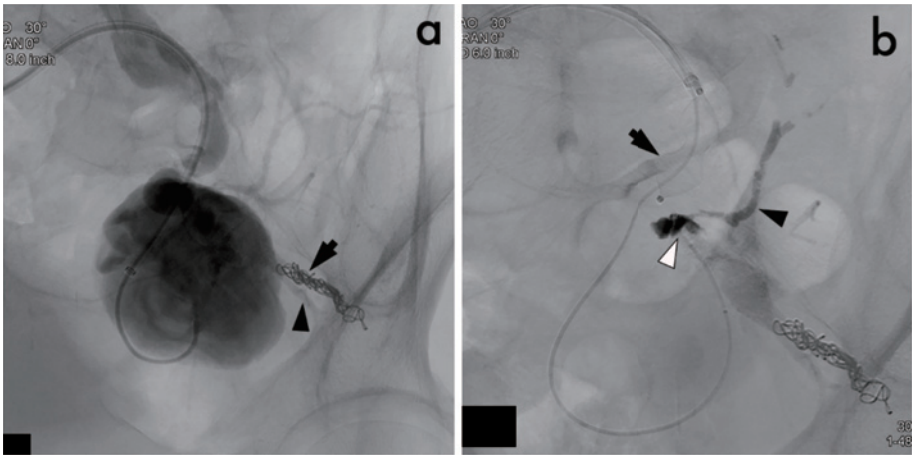

Fig. 5 An 81-year-old man with a left IIA aneurysm (Case 4).
After the distal segment of the IIA is embolized using coils (a, arrow) and glue (a, arrowhead), the AVP is deployed at the orifice of the left IIA (b, black arrow), and the iliolumbar artery (b, black arrowhead) is filled with glue injected via a steerable microcatheter (b, white arrowhead).

teric artery (**Fig. 4b**). One microcatheter was navigated through the PSPDA and advanced into the ASPDA, and another was navigated through the ASPDA and advanced into the pseudoaneurysm. Coils (C-stopper; Piolax, Yokohama, Japan) were placed at the segment from the ASPDA to the PSPDA across the rupture site. After that, 0.5 mL of 33% glue was injected into the neck of the pseudoaneurysm (**Fig. 4c**).

Case 4: An 81-year-old man presented with a 52-mm left IIA aneurysm. Although the other outflow vessels could be embolized with coils and glue, the iliolumbar artery could not be approached because of its anatomical location (**Fig. 5a**). After a vascular plug (16 mm of AVP) was deployed to the orifice of the left IIA, a steerable microcatheter (LEONIS Mova; Sumitomo Bakelite, Tokyo, Japan) that had been preloaded through the AVP was advanced near the orifice of the iliolumbar artery, and 1.3 mL of 33% glue was injected and flowed into the iliolumbar artery. The inside of the vascular plug was also filled with glue (**Fig. 5b**).

No problems with the device were observed, and removal of the microcatheter after glue injection was straightforward. Complete angiographic hemostasis of the target artery was achieved in all cases. The technical success rate was therefore 100%.

Clinical Outcomes

A review of adverse events revealed mild left gluteal pain in Case 4, which did not significantly affect walking and resolved within a few weeks. No rebleeding or other serious adverse events were observed in any patient during the follow-up period of 2-7 months. The clinical success was therefore 100%.

Discussion

The glue in lockdown technique involves using glue to fill target vascular lesions after inflow is occluded with metallic materials. A lesion with occluded inflow is like a city with a locked entrance, so we named this technique glue in lockdown.

During glue infusion, blood flow greatly affects the extent of glue within the vasculature, and blood flow control using balloon catheters has been advocated as an important maneuver to avoid unwanted glue distribution[4,12,13]. As a flow control method using coils, the pressure cooker technique was developed for injecting Onyx (ev3 Neurovascular, Irvine, CA, USA) to treat cerebral arteriovenous malformations[14]. Blood flow control using coils before injection of liquid embolization material is the main characteristic of both the pressure cooker and glue in lockdown techniques; however, these techniques differ in embolization materials and the main delivery devices. In the original pressure cooker technique, Onyx is injected via a tip-detachable microcatheter[14]. In the glue in lockdown technique, glue is injected via a normal microcatheter placed beyond the coils or the AVP, and the microcatheter is removed before adhesion.

In the case of proximal pulmonary artery pseudoaneurysm (Case 1), embolization of the orifice of the upper lobe artery with coils only increases the risk of coil migration because of its wide vessel diameter and the multiple shunts from systemic arteries. Although a vascular plug has the advantage of controlling the embolization

area[9], the precision of hemostasis is uncertain because of the complicated blood flow. Therefore, additional glue filling under residual blood flow through a still unthrombosed vascular plug provided uniform glue cast[8,9,15,16]. The patients with pseudoaneurysms at the distal pulmonary artery (Case 2) and pancreaticoduodenal arcade (Case 3) had coagulopathies due to massive bleeding and anticoagulation therapy. These lesions were approached using two microcatheters, and glue was injected after the coils were loosely placed at the proximal segment. The embolic effect is likely to be quicker and stronger than that achieved by using coils alone[6]. For a true IIA aneurysm (Case 4), the preloaded microcatheter was navigated close to the orifice of the iliolumbar artery. Residual blood flow through the unthrombosed vascular plug delivered glue into the iliolumbar artery. Then, simultaneous closure of the outflow via iliolumbar artery and inflow via the main trunk of IIA was required, and spontaneous thrombosis within the huge aneurysmal sac was achieved.

In all cases, complete arrest of flow before glue injection may have been associated with adhesion of the catheter with the glue-cast and metallic materials; hence, we ensured semi-occlusion first. Residual blood flow through an unthrombosed vascular plug or loosely placed coils may facilitate slow injection and promote uniform filling of the target segment.

This study has several limitations. The number of patients was insufficient for comparison with other techniques. Only short-term outcomes were examined; therefore, durability should carefully be studied.

In conclusion, the glue in lockdown technique successfully used glue to treat peripheral artery aneurysms/pseudoaneurysms. Device combinations can vary and further applications of this technique to treat other lesions are anticipated.

Conflict of Interest: The authors declare no conflict of interest.

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