



A Novel Technique for the Treatment of Type 2 Endoleak After Endovascular Aortic Repair: Sac Embolization with Balloon Occlusion of the Aorta (SEBOA)

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Abstract

Purpose We presented a new method of sac embolization using *n*-butyl-cyanoacrylate (NBCA) with balloon occlusion of the aorta (SEBOA) that can facilitate decreasing flow rate of the involved branches with the goal of type 2 endoleak resolution after endovascular aortic repair (EVAR).

Technique This technique is demonstrated in six patients who required type 2 endoleak treatment including previous technical failure. A transarterial approach was performed in four patients and transabdominal direct puncture in two. Technical success was defined as complete embolization of both involved branches and sac on postoperative CT. Sacography under balloon occlusion of the aorta demonstrated decreased flow rate of the all involved branches in all patients. SEBOA was performed using 25 or 33% of NBCA diluted with lipiodol. Technical success was obtained in 3 of 6 patients, and one major complication was

observed with adhesion of NBCA to the microcatheter resulting in foreign body retention.

Conclusion SEBOA may help solve the difficulty of type 2 endoleak treatment after EVAR as decreased flow rate of the involved branches under balloon occlusion of the aorta was achieved in all patients. However, protocols regarding concentration of NBCA or using other embolic materials are needed to improve the success rate.

Keywords Type 2 endoleak · Sac embolization · *n*-Butyl cyanoacrylate · Aortic balloon occlusion

Introduction

Treatment options of type 2 endoleak after endovascular aortic repair (EVAR) include transarterial, translumbar and transcaval embolization. Although the appropriate approach, embolic material used or embolic level are still being debated [1], both branch and sac embolization may help reduce the incidence of residual or recurrent type 2 endoleak [2, 3]. However, a complex vessel network feeding the aneurysm sac often does not allow us to cannulate involved branches by transarterial approach. Direct puncture allows the sac to be accessed easily, and *n*-butyl cyanoacrylate (NBCA) is often used as the main embolic material. Incomplete embolization, however, may occur if there is high flow in the sac from the involved branches that can make NBCA polymerized before NBCA reaches the orifice of these branches since NBCA is injected against inflow. Combination of branch embolization using a

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coaxial technique may solve this problem, but it is often difficult to catheterize these branches.

We hypothesized that balloon occlusion of the aorta decreases flow rate of these involved branches enabling wider distribution of NBCA, and complete embolization of both sac and involved branches without selective branch embolization (Fig. 1).

The purpose of this study was to investigate the clinical utility of this novel technique, sac embolization with balloon occlusion of the aorta (SEBOA).

Methods

Between February 2016 and October 2017, a total of six patients with persistent type 2 endoleak were treated by SEBOA. Indication of SEBOA includes enlarging aneurysm size with residual or recurrent type 2 endoleak after transarterial embolization ($n = 2$), or failure of catheterization of involved branches during type 2 endoleak treatment ($n = 4$) (see Table 1). When possible, selective embolization was performed to reduce the incidence of skin/muscle necrosis or neurological deficits that can occur when there is distal NBCA embolization of lumbar or median sacral arteries. All procedures were performed in a hybrid OR using the Infinix CeleveTM-i system (Toshiba Medical, Tochigi, Japan) under general anesthesia.

Technique:

1. In transarterial approach, a triple coaxial system consists of a 1.9-F microcatheter (Carnelian MARVEL; Tokai Medical, Aichi, Japan), 2.8-F microcatheter (Carry Leon; UTM, Aichi, Japan) and 5-F Cobra catheter (Medikit, Tokyo Japan) were used. An ilio-lumbar artery was selected using 5-F Cobra

catheter, and 2.8-F microcatheter was advanced to lumbar arteries as far as possible, and then, 1.9-F microcatheter was advanced into sac.

2. In direct puncture approach, 20-G PTCO needle (Medikit) was inserted to sac under ultrasound guidance, and a coaxial system using a 2.2-F microcatheter (Coiling Support; Goldcrest Medic, Tokyo, Japan) was used when selective branch embolization is necessary.
3. After approaching the sac via transarterial or direct puncture approach, a 7-F aortic balloon catheter (Tokai Medical) was placed in the proximal neck of a main body via the femoral artery. Aortic balloon occlusion is performed in the proximal neck of the main body in all patients.
4. Sacography by manually contrast material injection is performed without aortic balloon occlusion to evaluate the number and flow dynamics of the involved branches.
5. Repeated sacography with aortic balloon occlusion is then performed to confirm decreasing flow rate of all involved branches.
6. If the inferior mesenteric artery is patent, selective coil embolization is performed prior to SEBOA to prevent bowel ischemia.
7. After achieving distribution of contrast material to all involved branches, NBCA is mixed with lipiodol (Guerbet, Tokyo, Japan) in a 1:2 (33%) or 1:3 (25%), and NBCA is manually injected under aortic balloon occlusion until all involved branches are embolized.

Technical success was defined as complete embolization of all involved branches on CT after 1 week.

Aneurysms were considered to be enlarging if the maximal sac diameter increased by more than 5 mm after the procedure.

Fig. 1 Concept of sac embolization with balloon occlusion of the aorta (SEBOA). Sac embolization using *n*-butyl cyanoacrylate (NBCA) can cause incomplete embolization because of polymerization of NBCA before NBCA reaches the orifice of involved branches due to high flow in the sac from these vessels. SEBOA allows decreased flow rate of the hypogastric artery collaterals that enabling wider distribution of NBCA

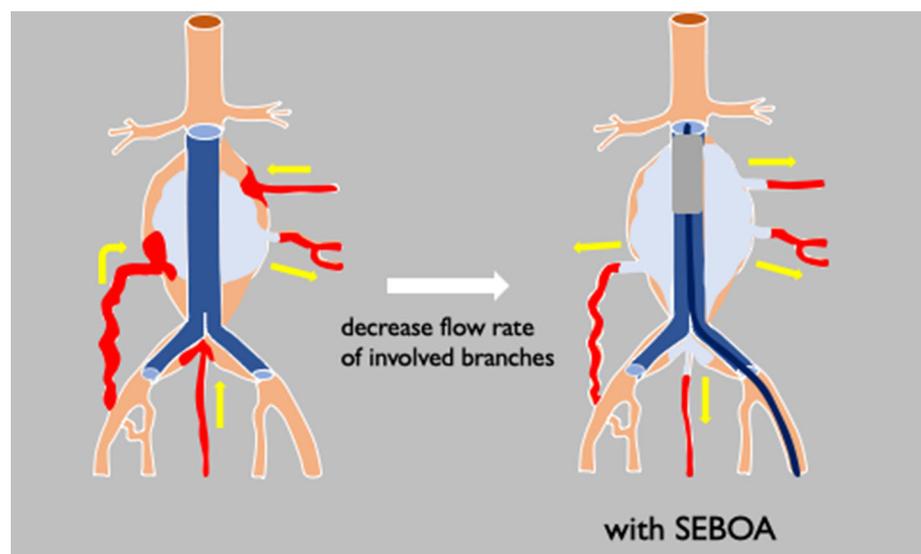


Table 1 Technical results and clinical outcomes

	Approach	Involved branches	Selective embolization	NBCA (ml)	Technical result	Complications	Interval (month)	Aneurysm size change
1	Direct puncture	rt. 3rd lumbar lt. 3rd lumbar	None	33% (9)	Failure	None	9	+ 1 mm
2	Transarterial	rt. 3rd lumbar rt. 4th lumbar	None	25% (3)	Success	None	4	0 mm
3	Transarterial	IMA bil. 3rd lumbar rt. 4th lumbar	IMA rt. 3rd lumbar	25% (8)	Success	Adhesion of NBCA to catheter	11	+ 1 mm
4	Transarterial	rt. 4th lumbar lt. 4th lumbar	rt. 4th lumbar	33% (0.5)	Success	None	7	+ 2 mm
5	Transarterial	IMA rt. 3rd lumbar lt. 3rd lumbar	IMA	33% (2.7)	Failure	None	23	+ 2 mm
6	Direct puncture	IMA rt. 3rd lumbar rt. 4th lumbar	IMA	33% (20)	Failure	None	11	+ 5 mm

NBCA *n*-butyl-cyanoacrylate, IMA inferior mesenteric artery, *bil* bilateral, *rt.* right, *lt.* left

As all devices used were approved for endovascular treatment, the approval of the ethics committee was waived for this procedure. Written informed consent was obtained from all patients.

Results

Transarterial approach was performed in four patients and transabdominal direct puncture approach in two who had a failure of transarterial approach. All four patients with transarterial approach were treated via 3rd or 4th lumbar arteries from the iliolumbar arteries.

Sacography under aortic balloon occlusion demonstrated decreasing flow rate of all involved branches in all patients.

Of the six patients, two were treated with 25% and four with 33% NBCA, respectively.

Technical success was achieved in three patients (50%). A major complication was seen in one patient with a microcatheter adhesion to the vessel wall.

The mean follow-up time was 10 months with no patient deaths observed. Aneurysm sac enlargement was seen in one patient, and five patients did not have aneurysm enlargement.

A 76-year-old man (Case 1) underwent direct puncture approach using a 20-G PTCO needle (Medikit, Tokyo, Japan), and sacography showed a pair of the 4th lumbar artery with inflow (left side) and outflow (right side) (Fig. 2A). Repeated sacography under aortic balloon

occlusion in the proximal neck achieved decreasing flow rate of these branches, and the left 4th lumbar artery was visualized distally (Fig. 2B). Sac embolization using 9 ml of 33% NBCA was performed via the outer needle under aortic balloon occlusion. However, NBCA did not reach the left 4th lumbar artery despite successful delivery of NBCA into both the sac and the right 4th lumbar artery (Fig. 2C). Contrast-enhanced CT after 1 week showed residual sac enhancement communicating with left lumbar artery (Fig. 2D). The patient is managed conservatively as no sac enlargement was observed 9 months after the procedure.

A 74-year-old woman (Case 3) underwent transarterial approach using a triaxial technique. Sacography demonstrated antegrade flow of the right 3rd and 4th lumbar arteries as outflow, but no visualization of the left 3rd lumbar artery (Fig. 3A). Repeated sacography under aortic balloon occlusion at the level of superior mesenteric artery revealed the appearance of the left 3rd lumbar artery and inferior mesenteric artery that suggested inflow into the sac (Fig. 3B). Coil embolization of the right 3rd lumbar artery and inferior mesenteric artery was performed, but the left 3rd lumbar artery was noted successfully cannulated.

Sac embolization using 8 ml of 25% NBCA was performed via the 1.9-F microcatheter with under aortic balloon occlusion in the proximal neck with broader distribution of NBCA. However, it resulted in adhesion of NBCA to the microcatheter (Fig. 3C), which resulted in it left in the right iliolumbar and 4th lumbar artery. Contrast-enhanced CT after 1 week showed complete embolization

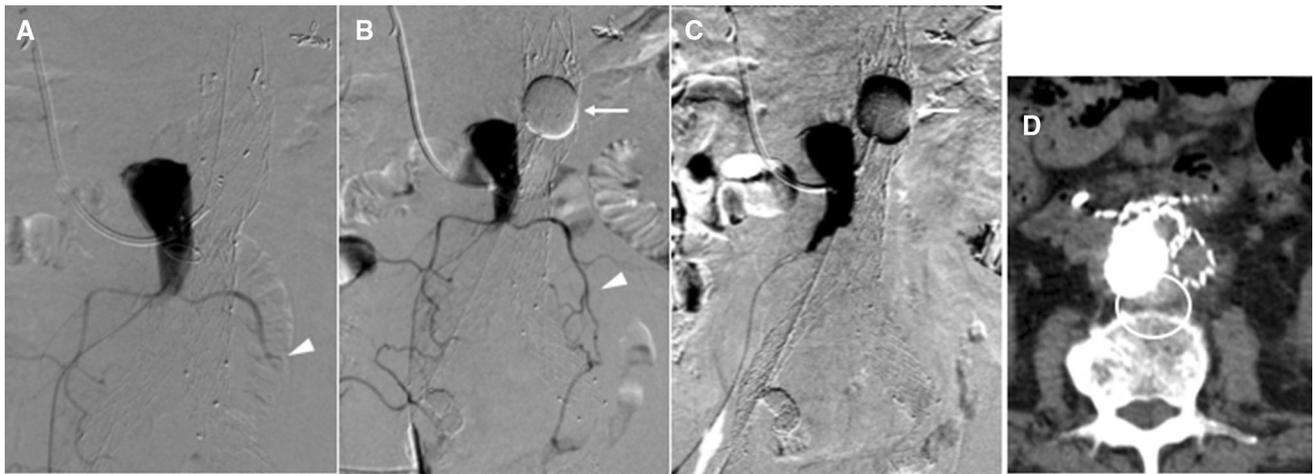
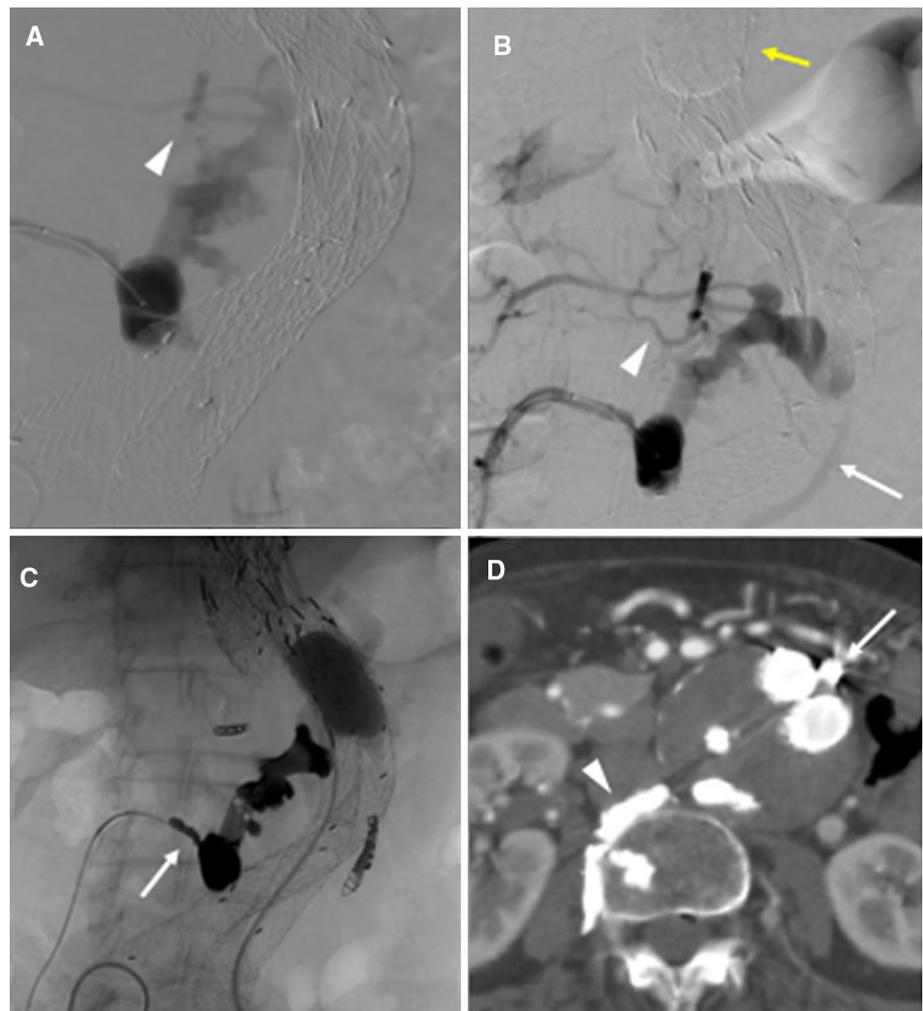


Fig. 2 A 76-year-old man (Case 1) with technical failure (transabdominal direct puncture approach). **A** Sacography shows an inflow of the right 4th lumbar artery and outflow of the left lumbar artery (arrowhead; to-and-fro). **B** Sacography with balloon occlusion of the aorta shows visualization of the left 4th lumbar artery distally

(arrowhead) (arrow; balloon catheter). **C** Sac embolization using 9 ml of 33% *n*-butyl cyanoacrylate (NBCA) under balloon occlusion shows NBCA did not reach the left 4th lumbar artery (arrow; balloon catheter). **D** Contrast-enhanced CT 1 week after the procedure shows residual sac communicating with the left 4th lumbar artery (circle)

Fig. 3 A 74-year-old woman (Case 3) with technical success (transarterial approach) with a complication of retention of the microcatheter. **A** Sacography (RAO 45°) shows the right 3rd and 4th lumbar arteries, but no visualization of the left 3rd lumbar artery (arrowhead) (arrow; microcatheter). **B** Sacography with balloon occlusion of the aorta (RAO 45°) shows appearance of the left 3rd lumbar artery (arrowhead) and inferior mesenteric artery (arrow) that suggests inflow (yellow arrow; balloon catheter). **C** The right 3rd lumbar artery and inferior mesenteric artery were coil embolized, but cannulation of the left 3rd lumbar artery was unsuccessful. Sac embolization using 8 ml of 25% NBCA under balloon occlusion of the aorta shows complete embolization with adhesion of NBCA to a 1.9-F microcatheter (arrowhead). **D** Contrast-enhanced CT 1 week after the procedure shows complete embolization (arrow; coil embolized inferior mesenteric artery, arrowhead; NBCA embolized right 4th lumbar artery with retained microcatheter)



(Fig. 3D), and she has no symptoms associated with the technical complication.

Discussion

Our experience with the SEBOA technique allowed for decreased flow rate of the involved branches in all patients treated. However, three patients failed to achieve technical success due to insufficient distribution of NBCA–lipiodol. It may be due to different viscosity of contrast material and NBCA, and polymerization time of NBCA does not always go as expected since determination of the dose, concentration, and speed of NBCA injection are operator-dependent factors.

This suggests that NBCA–lipiodol distribution during SEBOA needs further optimization.

We used 25 or 33% NBCA and hypothesized that lower concentration may achieve more extensive distribution. However, this may increase the risk of distal embolization. Besides, the location of the tip of the needle or microcatheter, injection speed and the volume of the sac also may influence NBCA distribution. Other embolic materials may solve these issues, and further studies are needed to optimize protocols.

A mixture of NBCA, lipiodol and ethanol (NLE) created by Kawai et al. [4] forms large droplets with a paste-like appearance that can make it control embolization range easily compared to NBCA–lipiodol. This has been performed to prophylactically embolize the sac during EVAR in 24 patients [5]. NLE was injected through a 3-F catheter after the stent graft deployment under proximal neck aortic balloon occlusion, similar to our reported technique. There was no adverse event including adhesion of NLE to the catheter and distal embolization, and only three patients had minor type 2 endoleak after the procedure. However, issues remain optimal concentration ratio, injection volume and a potential risk of distal embolization.

Onyx is a non-adhesive, permanent liquid embolic material that can fill the sac and the involved branches with minimal risk of nontarget embolization [6]. However, it is more expensive than NBCA and has been allowed to use in peripheral lesions in limited countries.

We performed aortic balloon occlusion in the proximal neck in all patients to avoid hypoperfusion of the superior mesenteric artery and both renal arteries, even for a short amount time. Furthermore, the suprarenal aorta often has atherosclerotic plaque or thrombus that may cause distal embolization. Although the infrarenal position will not induce flow inversion of the upper lumbar arteries, the most involved branches include the 3rd, 4th lumbar arteries or median sacral artery.

Yu et al. [7] compared the outcomes of sac only versus both sac and branch embolization in 29 patients with type 2 endoleak, and there were no significant differences in residual type 2 endoleak or change in aneurysm size. However, selection bias may have affected results, and approximately 40% of patients had continuous sac growth in both groups.

The described technique has several limitations. First, it will not work for the upper lumbar arteries or inferior mesenteric artery when aortic balloon occlusion is below the renal arteries.

Also, it still needs to consider appropriate embolic materials for this technique. Second, it is complicated to perform it in a patient in a prone position (translumbar approach). Transarterial approach has a potential risk of adhesion of NBCA to the catheter. We should stop NBCA infusion when NBCA reaches the tip of the catheter. Or transabdominal approach may be better when feasible.

An additional arterial approach may increase risks of access site complications, vessel injury or distal embolization. Therefore, this technique should be limited in a situation in which selective catheterization of the involved branches is difficult.

Furthermore, the evaluation of an endoleak by CT after embolization may be difficult and unsure due to metallic artifact due to the embolic agents. Additional evaluation using MRI and/or ultrasound should be considered when necessary.

Conclusion

SEBOA may help solve the difficulty of type 2 endoleak treatment after EVAR as decreased flow rate of the involved branches under balloon occlusion of the aorta was achieved in all patients. However, protocols regarding concentration of NBCA or using other embolic materials are needed to improve the success rate.

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Compliance with Ethical Standards

Conflicts of interest There are no conflicts of interest that could influence this study.

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