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Original Article

Endovascular Embolization of Femoral Pseudoaneurysm Associated with Therapeutic and Diagnostic Neuroendovascular Procedures

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Objective: We aimed to evaluate the usefulness of endovascular embolization for femoral iatrogenic pseudoaneurysms (PAs) following therapeutic and diagnostic neuroendovascular procedures.
Methods: This study included 12 patients with femoral PA due to femoral puncture at our department between May 2014 and April 2021. We performed an analysis of baseline characteristics, treatment, and outcome of these cases.
Results: Endovascular embolization was performed in 10 of the 12 PAs using coils and/or N-butyl-2-cyanoacrylate. Of these, 10 PAs were treated with endovascular embolization and 9 were successfully occluded, whereas complete occlusion was not achieved in 1 case of PA (success rate: 90%). No new intraoperative or postoperative complications or postoperative recurrences occurred.
Conclusion: Endovascular embolization for PA can be immediately performed under local anesthesia without discontinuation of antithrombotic therapy and may be a safe and effective option for access site complication treatment.

Keywords common femoral artery, access site complication, pseudoaneurysm, endovascular embolization, neuroendovascular procedures

Introduction

Recently, the number of endovascular procedures in the cerebrovascular and cardiovascular fields has increased dramatically due to the development of new devices. Access site complications (ASCs) are the most common complications in diagnostic or therapeutic catheterization, with a reported incidence of 1%–11% in cardiovascular and stroke interventions.[1–4] Local hematomas, dissections, pseudoaneurysms (PAs), arteriovenous fistulas, infected thrombi, and peripheral embolizations are common femoral ASCs. The incidence of PA is 0.1%−1.5% after angiography and up to 7.7% after interventional procedures.[5] As rupture of a PA can sometimes be lethal, early recognition and prompt and optimal management are essential.[1,3] Prior to 1990, open surgery was the preferred course of treatment for ASCs; however, less invasive techniques using echography or endovascular technology have since taken their place[6]. Nowadays, ultrasound-guided thrombin injection (UGTI) is the most preferred treatment for PA due to its safety and efficacy. However, recurrence rates of 6%−14% and rare complications such as allergic reactions to bovine thrombin, distal embolism, and neurological symptoms due to compression of adjacent nerves have been reported.[6,7]

At our department, we have treated femoral iatrogenic PAs using familiar materials, N-butyl-2-cyanoacrylate (NBCA) (Hystoacryl; B. Braun, Melsungen, Germany) and/or coils, with endovascular techniques that we routinely performed. In this study, we analyzed all patients with PA treated using endovascular embolization and report the effectiveness of the treatment by presenting two representative cases.

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Materials and Methods

Study population

This study included 12 patients who were suffering from femoral iatrogenic PA following neuroendovascular treatment or diagnostic cerebrovascular angiography via common femoral artery (CFA) at the Department of Neurosurgery of Nagareyama Central Hospital from May 2014 to April 2021. All CFA accesses were performed with a standard single-wall puncture with fluoroscopic guidance and palpation of the CFA pulse. If the patient had persistent worsening or newly developed swelling, subcutaneous hematoma, or pain at the femoral puncture site following the procedure, duplex sonography or contrast-enhanced CT was performed, depending on the patient's condition, and the PA was diagnosed.

Treatment

For PA, we first attempted treatment with ultrasound-guided compression (UGC), and when it failed, endovascular embolization was initiated. Endovascular treatment was attempted as a first-line treatment when it was impossible to treat the PA with UGC due to femoral skin lesion, pain, or delirium; when the situation was urgent due to a rapid decline in the hemoglobin level; or when the following three conditions were met: postoperative time-lapse was >48 hours, any anticoagulant was administered, and the PA was >30 mm and/or multi-lobed.

Endovascular embolization

A 4–5.2F sheath was inserted into the contralateral CFA or right brachial artery, and a 4−5F guide catheter was introduced into the affected CFA for diagnostic angiography to assess the exact status of the complication. The guide catheter or a microcatheter (its size depended on the embolic material) via the guide catheter was then inserted until it was stabilized in the neck of the PA, and when the catheter completely fit into the neck without contrast reflux, NBCA was injected near the neck. When the catheter was neither stable nor fit in the neck; when embolization with NBCA alone was presumed to be difficult because the PA was either large, not unilobed, or had unexpected extravasation; or when the arterial inflow velocity from the fistula was fast, the catheter was inserted until it became stable in the PA and the PA was coarsely embolized with coils. NBCA was then injected near the neck until the PA was not contrasted. If the PA disappeared with coil implantation alone, the NBCA injection was not added. The mixing ratio of NBCA and Lipiodol was adjusted for each case to ensure that they filled in near the neck and that NBCA did not reflux from the neck into the responsible artery.

We defined primary success as a complete resolution of the ASC by final angiography.

Metric variables are presented as mean ± standard deviation. Ethics approval for this retrospective study was obtained from the Institutional Review Board of Nagareyama Central Hospital.

Results

In total, 12 femoral PAs occurred after 1085 therapeutic and 1763 diagnostic neuroendovascular procedures using CFA puncture at our department during the study period of 7 years. The overall incidence of PA was 0.42%, 0.74% after therapeutic procedures, and 0.17% after diagnostic procedures.

Baseline characteristics and procedural data of all patients with PA are summarized in **Table 1**. The mean age of the patients was 73.4 (±13.7) years, the mean body mass index (BMI) was 21.7 (±3.6), and 50% were males. Five patients (41.7%) had hypertension, 4 patients (33.3%) had dyslipidemia, 1 patient (8.33%) had diabetes mellitus, and 3 patients (25%) were smokers. The reasons for the femoral puncture were mechanical thrombectomy (MT) in 5 cases, coil embolization for an unruptured aneurysm in 1 case, carotid artery stenting (CAS) in 1 case, diagnostic purpose in 3 cases, and treatment for symptomatic cerebral vasospasm after subarachnoid hemorrhage in 2 cases. Seven (58.3%) of these cases had to undergo urgent procedures. At the time of the sheath removal, all patients with ASCs received at least one antithrombotic agent. Hemostasis of the femoral puncture site was achieved using manual compression (MC) with or without hemostatic material in 10 cases and using vascular closure device (VCD) in 2 cases.

The mean PA size was 31.8 (±20.7) mm, and the mean time to treatment was 10.1 (±13.8) days. In two patients with PA, UGC was attempted, which successfully led to the occlusion of the PA. We attempted endovascular embolization with NBCA and/or coils in 2 PA cases after the failed UGC and in 8 other PA cases according to our criteria. The treatments achieved complete occlusion in 9 cases (success rate: 9/10 = 90%) and there were no new intraoperative or postoperative complications, such as distal embolization, a mass effect due to embolic material, or another ASC. In each case, duplex sonography was performed the day following the treatment and was used to

Table 1 Baseline characteristics and procedural data of patients with femoral iatrogenic pseudoaneurysm

Case no.	Age	Sex	Diagnosis	Urgency	Catheter procedure	Antithrombotic and/or thrombolytic agent	BMI	Risk factor	Smoking	Sheath size (Fr)	Hemostasis method	PA size (mm)	Time to treatment (day)	Treatment method	Result
1	70	F	Vasospasm after SAH	+	Fasudil I.A.	OZA + ASA + CLZ	24	HT, HL	–	4	MC	9	5	Coil	Success
2	69	M	AIS	+	MT	APX	20.7	HL	+	9	HP + MC	32	6	50% NBCA	Success
3	70	F	AN		Coiling	AGN + CLO + RIVA	21.3	HT, HL	–	6.2	HP + MC	42	5	33% NBCA + coil	Success
4	48	M	VA dissection		DSA	OZA + CLO	21	–	–	4	MC	18	2	Coil + 33% NBCA	Success
5	74	F	R ICS		DSA	OZA + ASA + CLZ	19.5	–	–	4	MC	3	7	UGC	Success
6	79	M	AIS	+	MT	CLO + Edo	20.3	HT, HL, DM	–	9	HP + MC	19	21	Coil	Success
7	80	M	AIS	+	MT	rt-PA + Edo	23.8	–	+	9	HD + MC	20	5	Coil + 50% NBCA	Success
8	96	F	AIS	+	MT	Edo	15.3	HT	–	9	MC	56	53	Coil + 50% NBCA	Success
9	90	F	AIS	+	MT	Edo	20.6	–	–	9	MC	78	5	Coil + 50% NBCA	Success
10	72	M	R ICS		CAS	CLO + APX	23	–	–	9	Angio-Seal	30	2	UGC→Coil + 20% NBCA	Success
11	84	M	R MCA stenosis		DSA	OZA + TLP	19.6	HT	+	4	MC	52	5	UGC→12.5% NBCA	Failure (surgery)
12	49	F	Vasospasm after SAH	+	PTA	OZA	31.3	–	–	7.2	Exoseal	23	5	UGC	Success

AGN: argatroban; AIS: acute ischemic stroke; AN: aneurysm; APX: apixaban; ASA: aspirin; BMI: body mass index; CAS: carotid artery stenting; CLO: clopidogrel sulfate; CLZ: cilostazol; DM: diabetes mellitus; Edo: edoxaban; F: female; HD: hemostatic dressing (HemCon Patch; HemCon Medical Technologies, Portland, OR, USA); HL: hyperlipidemia, means dyslipidemia; HT: hypertension; HP: hamostasis-pad (Tricell; Alliance Medical Group, Tokyo, Japan); ICS: internal carotid artery stenosis; M: male; MC: manual compression; MCA: middle cerebral artery; MT; mechanical thrombectomy; NBCA: N-butyl-2-cyanoacrylate; OZA: ozagrel Sodium; PA: pseudoaneurysm; PTA: percutaneous transluminal angioplasty; R: right; RIVA: rivaroxaban; rt-PA: alteplase; SAH: subarachnoid hemorrhage; TLP: ticlopidine; UGC: Ultrasound-guided compression; VA: vertebral artery

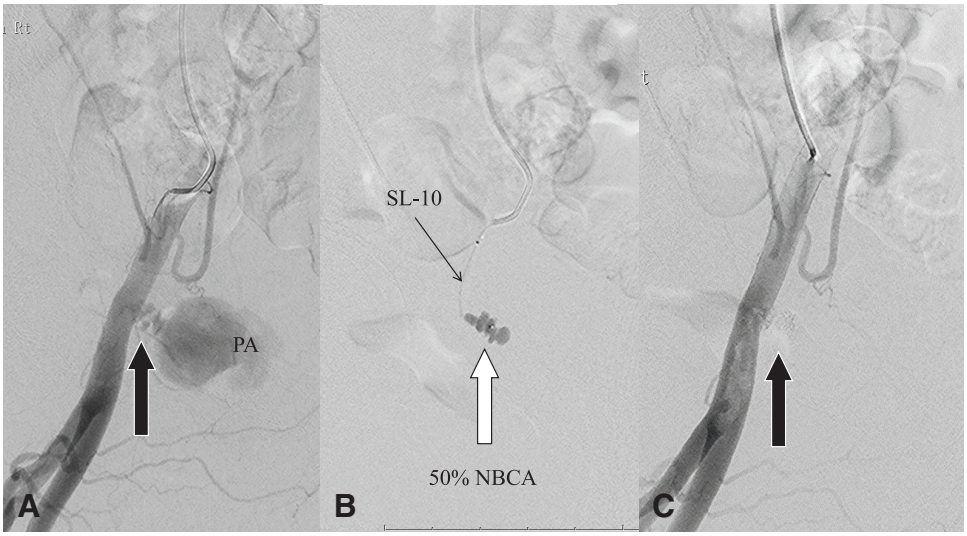

Fig. 1 A 69-year-old man underwent a MT for left middle cerebral artery occlusion using a right CFA puncture. On postoperative day 6, swelling was observed in the right inguinal region. (**A**) Angiography showed a PA emerging from the puncture site of the right CFA (black arrow: PA neck). (**B**) A microcatheter was placed in the neck of the PA and 50% NBCA was injected into the neck (white arrow). (**C**) The PA was no longer contrasted (black arrow). CFA: common femoral artery; MT: NBCA: N-butyl-2-cyanoacrylate; PA: pseudoaneurysm

validate the patency of the CFA and PA occlusion. During the median follow-up of 223.9 (±345.5) days, no individuals experienced recurrence. In cases in which long-term observation was possible, complete occlusion of the PA was confirmed via duplex sonography, contrast-enhanced CT, or angiography during the evaluation of the original cerebrovascular diseases. In Case 11, full occlusion was not achieved after embolization with 12.5% NBCA and the PA was treated subsequently with open surgery.

Two representative PA cases in which endovascular treatment led to successful resolution are presented below:

Case 2 (**Fig. 1**): A 69-year-old man underwent MT for left middle cerebral artery occlusion using a right CFA puncture. He had no postoperative neurological deficits and was taking apixaban. On postoperative day 6, swelling was observed in the right inguinal region, and a 32-mm PA was confirmed using duplex sonography. On the same day, under local anesthesia, embolization using an endovascular technique was performed. A 5.2F sheath was inserted into the left CFA and a 4F HHA (Medikit, Tokyo, Japan), together with a 0.035-inch guidewire, was advanced into the right common iliac artery. Following right CFA imaging, SL-10 (Boston Scientific, Natick, MA, USA) was placed in the neck of the PA and 50% NBCA was injected. The PA was no longer contrasted.

Case 10 (**Fig. 2**): A 72-year-old man underwent coil embolization of an unruptured aneurysm using a right CFA puncture and then a left CAS using a left CFA puncture 2 years ago. This time, he underwent a right CAS with a left CFA puncture. On postoperative day 2, inguinal swelling appeared and a 20 mm PA was diagnosed by duplex sonography. On postoperative day 6 during follow-up, the PA was found to be 30 mm in size. Attempts to thrombolize the PA with UGC failed, and endovascular embolization was subsequently performed. The right CFA was punctured under local anesthesia, and a 5F Flexor Ansel Guiding sheath ANL2 (Cook Medical, Bloomington, IN, USA) was inserted into the left common iliac artery. A 4F vertebral type TEMPO (Cardinal Health, Dublin OH, USA) was positioned in the neck of the PA under an oblique fluoroscopic view. Furthermore, a Headway 21 (Terumo, Tokyo, Japan) was advanced into the PA over a CHIKAI 18 (Asahi Intecc, Aichi, Japan) microwire, and three HydroFill (6 mm × 20 cm, 7 mm × 20 cm, and 6 mm × 20 cm; MicroVention/Terumo, Aliso Viejo, CA, USA) and two Target XL 360 soft (8 mm × 30 cm and 7 mm × 20 cm; Stryker, Fremont, CA, USA) were implanted. Subsequently, 20% NBCA was injected twice until the PA was not contrasted.

Discussion

At our department, 12 femoral PAs occurred after 2848 therapeutic and diagnostic neuroendovascular procedures (incidence rate: 0.42%). Ten PAs were treated with endovascular technique with NBCA and/or coils and complete

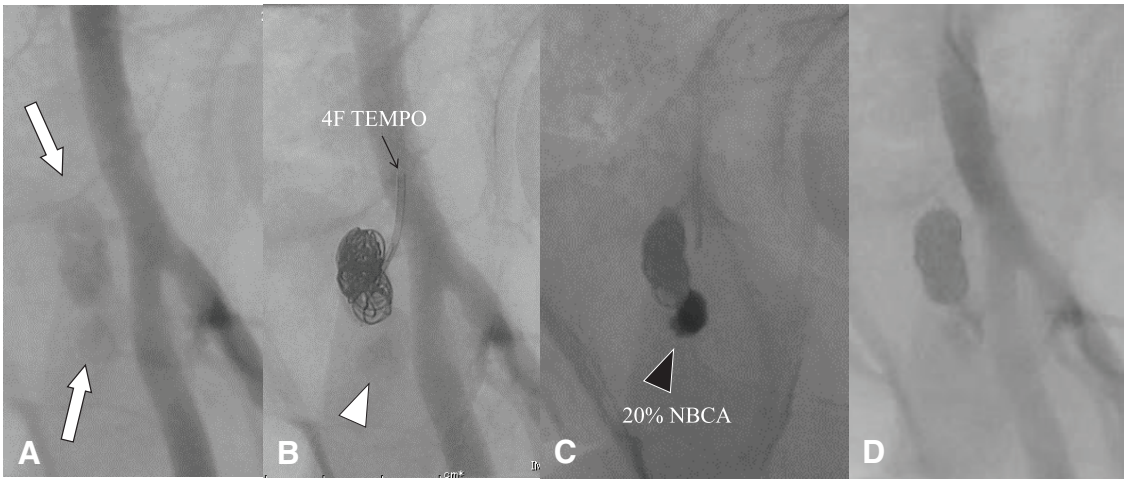

Fig. 2 A 72-year-old man underwent right CAS with a left femoral puncture. On postoperative day 2, a swelling appeared at the puncture site. (**A**) Angiography after failed treatment with UGC on postoperative day 6 revealed a multilobed pseudoaneurysm (PA: white arrows). (**B**) A 4F vertebral-type catheter was inserted into the PA coaxially with a microcatheter and then five coils were implanted. The caudal portion of the PA was still contrasted (white arrowhead). (**C**) Two injections of 20% NBCA were given (black arrowhead). (**D**) The PA was completely resolved. CAS: carotid artery stenting; NBCA: N-butyl-2-cyanoacrylate; PA: pseudoaneurysm; UGC: ultrasound-guided compression

occlusion was safely achieved in 9 cases (success rate: 90%). The incidence of femoral iatrogenic PA was comparable to previous reports.[5] Hirano et al. reported that the incidence, including asymptomatic cases, was 2.9% when routine duplex imaging was performed.[8] Patient-related risk factors for the development of femoral PA included older age, female, obesity, and decreasing platelet count. Procedural-related risk factors included puncture below the bifurcation of the CFA, large-bore sheaths, anticoagulant or antiplatelet agent use, and emergency procedures.[9] At our department, a 9F sheath was used in 6 of 12 cases with PA for the therapeutic procedures, and 5 of these 6 cases underwent MT. Because a large-bore sheath is commonly used for MT and postoperative antithrombotic therapy is mandatory, long-term attention should be paid to the delayed development of PA.

Observation with weekly duplex sonography can be taken into consideration for small (<2 cm), stable PAs up until thrombosis occurs. More aggressive intervention, such as UGC or UGTI, is necessary if a PA is greater than 2 cm, growing, or causing substantial discomfort, or if anticoagulation must be continued.[4,6] However, the current trend is to treat PAs once diagnosed, and to avoid prolonged hospitalization, decubitus complication, and increased cost.[10] Since our experience with the PA that grew during follow-up (Case 10), we have decided to immediately treat any PA that is diagnosed, regardless of its size.

Although UGC is less invasive and easy, the method has some disadvantages, such as prolonged procedure time and patient discomfort. Furthermore, postoperative time-lapse (>48 hours), obesity (BMI >28), fistula (>4 mm), PA size (>4 cm), and anticoagulants were factors that contribute to the failure rate of PA thrombosis by UGC, which was reported to be 31%−70%.[11–13] In the 2000s, UGTI has been recommended over UGC, with a 93%−100% primary success rate, but recurrence has also been reported to occur in 6%−14%, with risk factors being obesity (BMI >30), extensive use of combined antiplatelet and anticoagulation therapy, large PAs (≥6 cm), and complex (multilobed) PAs.[14–16] The complication rate was as low as 0%−1.2%, and even distal embolization, the most frequent consequence, occurred only 0.5%.[6,7] However, it should be not assumed that UGTI is completely safe, especially when performed by inexperienced hands, which carries a potential risk of more serious complications.[17]

In the past decade, various methods have also been reported, including percutaneous fluoroscopy- or ultrasound-guided PA embolization with coils or NBCA alone or in combination with endovascular techniques such as balloon-assisted technique to prevent distal embolization.[1,10,18] Griviau et al. found that femoral iatrogenic PAs had a 100% occlusion rate when the neck of the PA was sealed off using a balloon catheter inserted into the affected femoral artery.[10] The number of reports on the treatment of ASCs using only endovascular methods is currently increasing. Schahab et al. treated 12 patients with PA using stent grafts and reported no in-stent stenosis or stent fracture during the 1-year follow-up period.[1] At our department, as the puncture site

was relatively close to the bifurcation on the CFA in all PA patients, stent graft placement was excluded as a treatment option due to the risk of stent fracture.[19)]

A PA is a hematoma resulting from persistent leakage of arterial blood from a fistula of the arterial wall to adjacent extraluminal space. We originally used NBCA to embolize the fistula (PA neck) because we felt it was crucial to stop the leakage to promote thrombosis of PA. However, we found it difficult to fill a PA with just NBCA when the arterial inflow velocity from the fistula was fast or when the PA was large, not unilobed, or had unexpected extravasation. Therefore, we initially roughly embolized such PAs with coils before injecting NBCA. As a result, complete PA closure was obtained in 9 of 10 cases. The PA in Case 11 was diagnosed on postoperative day 3. Its size was 52 mm, but its form was simple (unilobed), so UGC was first attempted but failed and the PA was subsequently treated with 12.5% NBCA. The final angiography showed complete occlusion of the PA, but on the following day, recanalization was confirmed by duplex sonography, and open surgery was required. We believe that more case studies are needed to determine which factors contribute to failure and recurrence.

Endovascular PA embolization is less invasive than surgical techniques and can be done right away after a diagnostic procedure under local anesthesia without delaying antiplatelet therapy. After the treatment, ambulation is probable the next day. Endovascular surgeons may be able to complete the procedure with a high rate of technical success using their skills. However, the contralateral CFA or brachial artery must be punctured again, which can lead to new ASCs.[10)] Additionally, because the microcatheter is unstable in a big conduit like the CFA, it can occasionally be exceedingly challenging to guide the device into a PA. To stabilize a microcatheter, first, any support catheter must be guided into the neck of the PA and placed. Technically speaking, a vertebral type catheter, such as the 4F TEMPO, was more effective than the headhunter type catheter, such as 4F HHA, because the former captured the neck of the PA more easily and was stable when guiding the microcatheter in some of our cases. Coil deviation into the main vessel or NBCA reflux with subsequent distal embolization may be a problem with our approach. By inserting the guiding catheter deep into the neck of the PA and carefully injecting NBCA in real time under fluoroscopic guidance, we were able to circumvent this issue. Another preventive strategy, according to other authors, is to place a balloon catheter at the blood inflow site.[18,20)]

Prevention of ASCs

The use of large-bore sheaths is one of the risk factors for ASCs,[3,9)] and various VCDs have been developed to achieve hemostasis at the puncture site. However, when compared with MC, the usage of these VCDs did not reduce the incidence rate of ASCs.[2)] At our department, endovascular embolization was necessary for three cases with PA who underwent angiography with a 4F sheath. We believe that thorough hemostasis by MC is important to prevent ASCs, regardless of the diameter of the sheath used and without relying on VCD. Several centers have reported ultrasound-guided CFA punctures.[21,22)] The use of ultrasonography decreased ASCs while simultaneously speeding up puncture times. This method may be particularly useful in patients who have unpalpable CFA pulsation and have had several punctures at the same access site. Recently, we have been performing routine postoperative duplex sonography on patients who have undergone neuroendovascular procedures to detect ASCs as early as possible.

Study limitation

The number of cases in this study was small, and the statistical power was insufficient to thoroughly investigate various potential risk factors because it was conducted retrospectively in one neurosurgical department. In addition, long-term follow-up was not possible for some patients due to reasons such as transfer to other hospitals.

Further studies are needed to determine what factors are indications for endovascular treatment or contribute to good outcomes, and what the long-term outcome is.

Conclusion

Endovascular treatment for PAs can be carried out while under local anesthetic without requiring a bailout from antithrombotic therapy. Endovascular embolization with coils and/or NBCA appears to be a safe and effective treatment option for ASC.

Disclosure Statement

The authors declare that they have no conflicts of interest.

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