Successful treatment of ruptured extracranial carotid artery aneurysm and fistula associated with neurofibromatosis type 1: Report of two cases

Ryutaro Onaga, Toru Sasaki, Tomohiko Yamauchi, Katsunari Namba, Ayuho Higaki, Akira Gomi and Hiroshi Nishino

Department of Otolaryngology, Head and Neck Surgery, School of Medicine, Jichi Medical University, Tochigi-ken, Japan; Division of Neuroendovascular Surgery, Center for Endovascular Therapy, Jichi Medical University, Tochigi, Japan; Department of Neurosurgery, Jichi Medical University, Tochigi, Japan

ABSTRACT
Neurofibromatosis type 1 is an inherited disease. Vascular malformation represents minor complication but the rupture is fatal. We report two cases of ruptured vascular malformation in extracranial carotid artery who survived after successful treatment. Case 1 was a 35-year-old man who presented with airway obstruction due to a mass in the pharynx. The mass was diagnosed as ruptured aneurysm of the right internal carotid artery (ICA). An emergent treatment of superficial temporal artery to middle cerebral artery (STA–MCA) bypass surgery followed by endovascular occlusion of the right ICA was conducted. Case 2 was a 55-year-old man who presented with dyspnea associated with right-side neck swelling. Angiography showed two major high-flow arteriovenous fistulas, mainly fed from the ICA and maxillary artery. The patient also underwent embolization. Early diagnoses and appropriate managements of these rare cases could save lives after the serious condition.

ARTICLE HISTORY
Received 30 August 2021
Revised 11 January 2022
Accepted 14 February 2022

KEYWORDS
Neurofibromatosis type 1; aneurysm; arteriovenous fistulas; airway obstruction; endovascular treatment

Introduction
Neurofibromatosis type 1 (NF-1) is inherited in an autosomal dominant manner and is basically benign unless associated with fatal complications. The main clinical features of NF-1 are ectodermal, and include café-au-lait macules, neurofibromas, and Lisch nodules [1]. Vascular abnormalities are minor complications of NF-1, which commonly involve cerebral blood vessels and renal arteries. Aneurysm of the carotid artery is rare and cases of NF-1-related ruptured aneurysms of other arteries have been treated by surgical ligation of the affected arteries [2–4]. Since ligation of the carotid artery could result in cerebral ischemia and infarction; some groups have recommended endovascular treatment [5,6]. We herein report two rare cases of NF-1 with ruptured extracranial carotid artery aneurysms who survived after optimal treatment that included endovascular procedures.

Case presentation
Case 1
A 35-year-old man with the diagnosis of NF-1 presented at the Emergency Department of our hospital with the complaint of sudden right-side throat pain, trismus and difficulty in swallowing few days earlier. The right submandibular area was swollen and right-side facial palsy was evident. Nasopharyngeal endoscopy disclosed swollen right pharyngeal wall. Computed tomography (CT) showed a soft tissue density mass with partially high density lateral to the internal carotid artery (ICA), measuring 44 × 52 mm in diameter.

On day 4 of admission, upper airway obstruction deteriorated and tracheotomy was performed. On day 5 magnetic resonance imaging (MRI) showed hematoma surrounding the internal carotid artery (ICA), extending from the first to the second cervical vertebra and rupture of a dissociative aneurysm in ICA was strongly suspected (Figure 1). On day 7, cerebral angiography demonstrated that the right anterior circulation had poor collaterals from the anterior or posterior communicating arteries and rupture of a dissociative aneurysm in ICA was strongly suspected. Based on these findings, balloon occlusion test and trapping of the right ICA with or without a bypass were planned in the subacute period.
The patient was closely observed with cervical CT follow up. On day 20, bleeding started again, with life-threatening hematemesis requiring urgent pharyngeal packing. The treatment team included otolaryngologists, neurosurgeons and neuroendovascular surgeon decided on an emergent treatment with right superficial temporal artery to middle cerebral artery (STA-MCA) bypass surgery, followed by endovascular occlusion of the right ICA. A high-flow bypass was deemed ideal, but the bleeding was unstable, and the patient precluded the invasive procedure. The right ICA, including the aneurysm, was then trapped using coils and n-butyl-cyano acrylate (NBCA), resulting in complete hemostasis (Figure 3(a,b)). On day 20, this treatment was conducted as planned, with satisfactory results without any subsequent bleeding. Though the facial palsy persisted, cerebral infarction was avoided. Tracheotomy was closed on day 213 and the patient was discharged on day 227.

**Case 2**

A 55-year-old man with NF-1 presented at the emergency department of our hospital with the complaint of right-side swelling of the neck, neck pain with coughing and difficulty in breathing. Nasopharyngeal endoscopy showed complete pharyngeal obstruction and urgent cricothyroidotomy and tracheotomy were performed. On day 3, enhanced CT showed large hematomas at the bifurcation of the right common carotid artery, ICA and external carotid artery (ECA), measuring with total diameter of 100 × 90 mm, extending from the first to the fifth cervical vertebra (Figure 4(a,b)). Angiography showed two major high-flow arteriovenous fistulas (AVFs) in the right cervical area supplied by the main trunk of the right ICA and the internal maxillary artery, along with other small AVFs. The fistulas formed two venous pouches that converged into a common channel, subsequently draining into the right external jugular vein. Although no extravasation was detected on the angiogram, AVF rupture was diagnosed as the cause of the bleeding. On day 7, the patient developed massive bleeding in the right side of the neck accompanied by left hemiparesis. CT of the brain revealed acute cerebral infarction in the right middle cerebral artery area, presumably caused by compromised right ICA blood flow caused by the compressing hematoma and systemic hypotension. Urgent transarterial and transvenous embolization of the draining venous pouches and trapping of the affected and internal maxillary artery were performed using coils and NBCA. Embolization resulted in near-complete obliteration of the arteriovenous shunt and cessation of brisk bleeding. However, slowly developing hematoma and oozing continued, requiring attempted compression hemostasis and blood transfusion. Angiography on day 25 revealed a small residual AVF supplied by the
right posterior auricular artery, which was embolized with NBCA, resulting in complete hemostasis and stabilization of the hematoma (Figure 5(a,b)). Although common carotid artery ligation was also considered, it was anatomically difficult to perform because of the hematoma. Subsequently, the patient developed a large infectious skin ulcer due to compression ischemia caused by the giant hematoma, which required long-term treatment with antibiotics.

Figure 3. Case 1. Angiography obtained before (3a) and after (3b) embolization.

Figure 4. Case 2. Contrast-enhanced computed tomography shows extravasation from the right extracranial internal carotid artery and maxillary artery.

Discussion

NF-1 is a multisystemic disease characterized by pigmentary skin changes, increased susceptibility to cancer formation, neurological deficits and skeletal defects [1]. The vascular complications of NF-1 are well recognized, the reported incidence of NF-1 varies from 0.4% to 6.4%. Furthermore, the reported vascular complications of NF-1 include aneurysms, stenosis and arteriovenous fistula [2–4]. Vascular disease is
the second leading cause of death after malignant neoplasm in NF-1 patients [7]. Malformations are commonly found in medium and large-sized arteries. The early reported vascular complications of NF-1 are those of renal arteries. In 1945, Reubi [8] classified the renal artery lesions into three types in a classification set that targeted less than 1 mm diameter renal artery vessels. In 1973, Salyer and Salyer [9] classified renal artery lesions pathologically into four types; pure intimal type, advanced intimal type, intimal aneurysmal type, and nodular type, though many overlap types also existed. Irrespective of the classification, the etiology of vasculopathies in NF-1 remains poorly understood at present.

Treatment of aneurysms in NF-1 patients has evolved. Hamasaki et al. [5] reviewed 7 cases of extracranial ICA pseudoaneurysms in patients with NF-1, including two with ruptured pseudoaneurysms. Of the 7 reviewed, two were treated by open surgery, though aneurysm surgical repair was described as difficult. The vessels were fragile in these patients and based on the uncertainty about circulation distal to the aneurysm, the authors discussed the use of various stent types and concluded that endovascular treatment was safe and effective.

Bargiela et al. [6] reviewed 66 cases of NF-1-associated aneurysms that underwent endovascular treatment. They included 14 aneurysms in arteries of the head and neck. Of these 14, 13 patients were symptomatic, 8 had ruptured aneurysms, 2 required airway management [10,11], and all 14 were treated by coil or stent graft, and only one patient died [11]. Furthermore, 2 of the 14 required airway management; with one requiring intubation while the other underwent tracheotomy. They also explain the raison d'etre for aneurysm; vasculopathy in NF patients can be attributed to the alteration of neurofibromin, which is expressed in endothelial and smooth muscle cells. The authors concluded that endovascular management is safe and effective for both ruptured and unruptured aneurysms.

They also reviewed the procedure to treat aneurysms and pseudoaneurysms in patients with NF-1, including coiling, stenting, balloon placement, and embolization with NBCA glue. The most commonly used technique was coiling (83.3%), mainly because an unstable situation with active bleeding requires more secure treatment. Coiling or embolization with NBCA can prevent bleeding more quickly and accurately. However, a stable situation with nearly controlled bleeding and only mass effect requires more minimally invasive techniques. Stenting, including covered stents and self-expandable covered grafts, is suitable for stable conditions.

Airway management is important in patients admitted to the Emergency Department. When oxygen administration is inappropriate, the physician should consider intubation. However, the presence of neck mass often causes failure of intubation and difficulty of understanding neck anatomy for cricothyroidotomy and tracheotomy. Furthermore, puncturing hematomas with a needle should be avoided since it may result in unstoppable bleeding. Fortunately, in our two cases the hematoma was not anterior to the

![Figure 5. Case 2. Angiography obtained before (5a) and after (5b) embolization.](image-url)
Our experience shows that treatment of ruptured aneurysms of the carotid artery and its branches requires special precautions for the following three risks: airway obstruction, massive bleeding and cerebral infarction. Because progressive bleeding may compromise the airway, intubation or tracheostomy should be considered to guarantee patent airway before embarking on vascular treatment. Massive bleeding will lead to hypovolemic shock and may prove fatal. For imminent massive bleeding from the aneurysm, urgent surgical ligation should be the last resort, since it could cause cerebral infarction. When embolization of the aneurysm is planned, angiography is strongly recommended in advance, because the blood supply to the whole brain is not guaranteed following embolization. Angiography performed before embolization in Case 1 showed that the right anterior circulation had poor collateral from the anterior or posterior communicating arteries. Based on this finding, the patient was scheduled for STA–MCA bypass before embolization of the right ICA. This staged treatment saved the patient from cerebral ischemia and cerebral infarction.

**Conclusion**

Neurofibromatosis type 1 patients are at risk of ruptured vascular malformation. Endovascular treatment is recommended for extracranial carotid artery ruptured, but steps should be carefully planned and executed to prevent airway obstruction, excessive bleeding, cerebral infarction, and death.

**Acknowledgements**

The authors thank Editage (www.editage.com) and Wordmedex (https://www.word-medex.com.au) for English language editing.

**Informed consent statement**

The authors have obtained a written consent from each patient to the inclusion of material pertaining to the patient.

**Disclosure statements**

The authors have no conflict of interest to declare.

**References**

[1] Oderich GS, Sullivan TM, Bower TC, et al. Vascular abnormalities in patients with neurofibromatosis syndrome type I: clinical spectrum, management, and results. J Vasc Surg. 2007;7(1):475–484.

[2] Lin AE, Birch PH, Korf BR, the NNFF International Database Participants, et al. Cardiovascular malformations and other cardiovascular abnormalities in neurofibromatosis 1. Am J Med Genet. 2000;95(2):108–117.

[3] Hamilton SJ, Friedman JM. Insights into the pathogenesis of neurofibromatosis 1 vasculopathy. Clin Genet. 2000;58(5):341–344.

[4] Friedman JM, Arbiser J, Epstein JA, et al. Cardiovascular disease in neurofibromatosis 1: report of the NF1 cardiovascular task force. Genet Med. 2002;4(3):105–111.

[5] Hamasaki O, Ikawa F, Hidaka T, et al. Extracranial internal carotid artery pseudoaneurysm associated with neurofibromatosis type 1 treated with endovascular stenting and coil embolization. Vasc Endovasc Surg. 2014;48(2):176–179.

[6] Bargiela D, Verkerk MM, Wee I, et al. The endovascular management of neurofibromatosis-associated aneurysms: a systematic review. Eur J Radiol. 2018;100:66–75.

[7] Rasmussen SA, Yang Q, Friedman JM. Mortality in neurofibromatosis 1: an analysis using U.S. death certificates. Am J Hum Genet. 2001;68(5):1110–1118.

[8] Reubi F. Neurofibromatose et lesions vasculaires. Schweiz Med Wochenschr. 1945;75:463–465.

[9] Salyer WR, Salyer DC. The vascular lesions of neurofibromatosis. Angiology. 1974;25(8):510–519.

[10] Smith BL, Munschauer CE, Diamond N, et al. Ruptured internal carotid aneurysm resulting from neurofibromatosis: treatment with intraluminal stent graft. J Vasc Surg. 2000;32(4):824–828.

[11] Hoonjan B, Thayur N, Abu-Own A. Aneurysmal rupture of the costo-cervical trunk in a patient with neurofibromatosis type 1: a case report. Int J Surg Case Rep. 2014;5(2):100–103.

[12] Seow VK, Chong CF, Wang TL, et al. Ruptured left subclavian artery aneurysm presenting as upper airway obstruction in von recklinghausen’s disease. Resuscitation. 2007;74(3):563–566.