ORIGINAL ARTICLE

Deconstructive vs. reconstructive endovascular treatment paradigms in acute carotid blowout

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ABSTRACT

BACKGROUND: Carotid Blowout (CBO), a neuro-oncological emergency characterized by the rupture of the carotid artery, has been predominantly reported in patients with head and neck cancer who have undergone radiation therapy. In this study, our objective is to share our experience with deconstructive and reconstructive endovascular treatments for CBO.

METHODS: This study includes 17 patients who experienced intractable acute CBO, presenting with ear, oral, or nasal bleeding, between 2003 and 2022. We employed deconstructive embolization using vascular plugs, expanding hydrogel coils, glue, and balloons. If vascular anatomy and pathology permitted, we opted for reconstructive treatment using a covered stent. All patients underwent clinical follow-up visits, and we used the modified Rankin Scale to evaluate the clinical success of the procedures. We compared outcomes in terms of complications between the deconstructive and reconstructive treatment methods using the Chi-square test.

RESULTS: The patient cohort had an age range of 20–64 years (mean 50.9), including three females (18%) and 14 males (82%). We conducted 15 endovascular procedures on 14 patients during 19 angiography sessions. All 15 treatments achieved immediate hemostasis, resulting in complete technical success (p=1.0). Six patients (35%) underwent reconstructive treatments with covered stents in the internal carotid artery, while nine patients (65%) underwent deconstructive embolization in either the external or internal carotid artery. We found no significant association between the treatment paradigms (deconstructive vs. reconstructive) and the development of complications using a Chi-square test of independence X^2 (2, n=15)=0.07, p=0.79.

CONCLUSION: Recent advancements in endovascular treatments have shown promising results in managing life-threatening acute CBO cases. Our study found no significant difference in outcomes between deconstructive and reconstructive endovascular paradigms in such patients. However, it is important to note that the available data, including ours, is heterogeneous and scarce, necessitating higher levels of evidence to draw more definitive conclusions.

Keywords: Carotid blowout; carotid rupture; covered stent; embolization.

INTRODUCTION

Carotid blowout (CBO), a neuro-oncological emergency, was first identified as a surgical complication in patients with head and neck cancers.[1-3] The weakening of the vessel wall due to irradiation was believed to be the primary cause of carotid artery rupture.[2,3] Additional pathologies, such as tissue necrosis, tumor recurrence, fistula formation, and infection, were also documented.[1,2] The incidence of CBO in these patients was estimated to be between 5-10%, with reported average mortality and morbidity rates as high as 50%.[1,4] Given that the presentation and incidence of actual emergency cases remain unclear, neuroimaging can play a crucial role in determining the appropriate triage and intervention for these patients.[5,6] Over the past few decades, the treatment paradigm for CBO has evolved from surgical intervention to endovascular management with vessel occlusion, and more recently, to reconstructive methods involving stent placement. However, all

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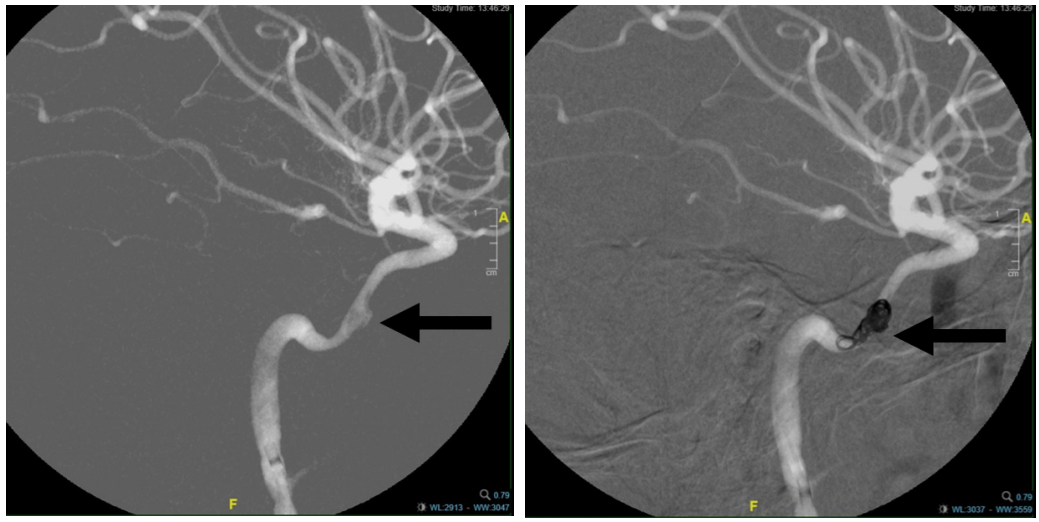

Figure 1. A 49-year-old male, previously treated for nasopharyngeal cancer, presented to the emergency department with massive oral and nasal bleeding unresponsive to compression methods. **(a)** DSA in lateral projection revealed irregularities in the cavernous segment of the internal carotid artery and the formation of a pseudoaneurysm. **(b)** DSA roadmap image captured during the deployment of the first long and oversized hydrocoil, placed in and around the pathological area.

these treatments come with their own set of complications, and there is no clear consensus in the literature supporting one method over the other.[7-9]

In this retrospective observational study, we aim to share our experience with both deconstructive and reconstructive endovascular treatments in acute, life-threatening CBO cases. We have compared the outcomes between the two treatment groups and have discussed our findings in the context of the existing literature.

MATERIALS AND METHODS

Between 2003 and 2022, we included 17 patients with intractable acute CBO, presenting with ear, oral, or nasal bleeding, in our study. All patients were referred to one of the tertiary centers for embolization treatment. Despite this being a multicenter study, all interventions were performed by an interventional radiologist from the same practice group, specializing in neuro-interventional radiology. Initial management for all patients involved securing the airway, followed by optimal bleeding control through pressure application, fluid resuscitation, and blood transfusion. The patient population presented with various head and neck cancers, with nasopharynx cancers being the most common. All cases of pharynx and larynx cancers were at least stage 4a, showing skull base invasion, and all patients had undergone chemoradiation therapy and induction therapy with platinum-based regimens as first-line treatment. Surgery was performed on only three patients; two as a first-line treatment, and one as salvage therapy for a recurrent nasopharynx cancer tumor following radiotherapy. All patients had previously undergone radiotherapy, receiving cumulative radiation doses of 70 Gray or more, and employing various radiotherapy modalities at least six months prior to the CBO incident.

Digital Subtraction Angiography (DSA) was utilized to ascertain the anatomy and location of potential active bleeding sites, regardless of whether patients had undergone non-invasive angiographic imaging. Active contrast agent extravasation or the presence of a pseudoaneurysm in the common carotid artery (CCA), internal carotid artery (ICA), or external carotid artery (ECA) constituted an indication for emergency endovascular treatment.

Our equipment included 5F diagnostic catheters, unilateral or bilateral 5-10F sheath compatible with treatment catheters, and microcatheters as required. For embolization, we used vascular plugs (Amplatzer, St. Jude Medical, Plymouth, MN), expanding hydrogel coils (AZUR; Terumo Medical Corporation, Somerset, NJ) of various sizes suited to the parent artery and vascular pathology (Fig. 1 a,b), and a 1/3 n-butyl-cyanoacrylate (NBCA)/lipiodol oil mixture for liquid embolization. Coil deployment was utilized as needed, ensuring the microcatheter position and anatomy were safe before performing instant microcatheter withdrawal post-injection. Covered stents were placed when deemed necessary by the vascular anatomy and pathology (Wallgraft, Boston Scientific, Ireland; BeGraft, Bentley Innomed, Hechingen, Germany; and LifeStream, Bard Peripheral Vascular, Tempe, AZ) (Fig. 2). Post-stenting, a loading dose of clopidogrel (150 mg) was administered via a nasogastric tube, followed by a daily 75 mg dose, and heparinization commenced with a 5000 units loading dose, followed by an infusion dose of 25U/kg/hour (Fig. 2 a,b).

Given the emergency nature of the treatment and the unconscious state of the patients, routine test occlusion was not performed. However, a venous filling delay of less than two seconds prior to embolization material detachment in

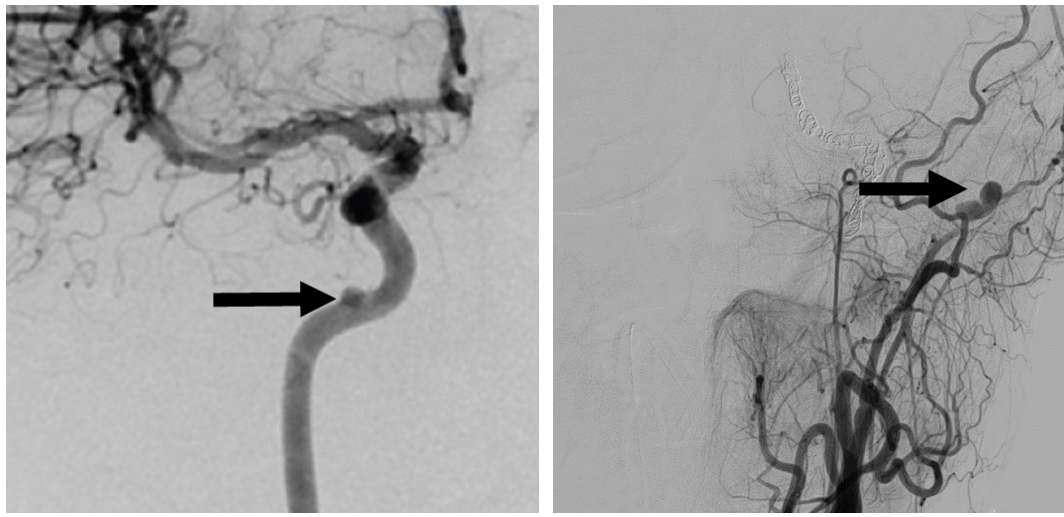

Figure 2. A 45-year-old male with nasopharyngeal cancer presented with intractable oral and ear bleeding.. **(a)** DSA in AP projection demonstrated a pseudoaneurysm in the petro-cavernous segment of the internal carotid artery. **(b)** The placement of a covered stent successfully excluded the pseudoaneurysm sac from the circulation.

the ICA was considered satisfactory.[10] Complete technical success was defined by control angiography, which showed no visible signs of the previous pathology. Post-procedure, mean blood pressure was maintained above 100 mm/Hg to prevent hypotensive issues. All patients underwent follow-up through clinical visits and hospital information system records, with neurological complications noted and the clinical success of procedures assessed using the modified Rankin Scale (mRS) at admission and one month post-discharge.

This retrospective study received approval from the institutional ethical committee, and a consent form for data usage was obtained from all patients.

Statistical Analysis

For the analysis of single categorical variables, such as patient's gender, age, treatment methods, and outcomes, we employed descriptive statistics, including frequency, percentage, and mean. Complications were compared between the deconstructive and reconstructive groups using the Chi-square test. A p-value of less than 0.05 was deemed statistically significant. All statistical data editing and analysis were conducted using SPSS 25.0 software (IBM Corp.).

RESULTS

This study encompassed 17 patients with acute CBO, ranging in age from 20 to 64 years (mean 50.9), including three females (18%) and 14 males (82%). A total of 15 embolizations—six reconstructive and nine deconstructive—were conducted on 14 patients during 19 angiographic procedures. Three patients (18%) experienced spontaneous Internal Carotid Artery (ICA) occlusion; one of these patients (33%) died before being transferred from an external center, while the other two underwent Digital Subtraction Angiography (DSA) confirming total ICA occlusion. DSA was repeated after a week to rule out recanalization and potential bleeding during follow-up in the Intensive Care Unit (ICU).

Eight patients (47%) underwent nine embolizations (five in ICA, four in External Carotid Artery (ECA)), utilizing hydrogel coils for four patients, n-butyl-cyanoacrylate (NBCA) for three patients, vascular plugs for two patients, and a balloon for one patient. One case of amaurosis fugax was observed in this deconstructive group. Furthermore, recurrent bleeding from an ECA branch occurred one month after ICA embolization in the same patient. Six patients (35%) received reconstructive treatment with covered stents in the ICA. In this group, one patient experienced transient motor aphasia several hours post-procedure. Aside from these instances, the Modified Rankin Scale (mRS) scores remained consistent during postoperative recovery and at the one-month follow-up. Both treatment groups had three patients (21%) experiencing temporary complications. Notably, no patients suffered from permanent neurological complications, devastating rebleeding, or death following the endovascular treatments. Demographic data of the patients, DSA findings, and endovascular treatments are detailed in Table 1.

The statistical analysis showed that technical success, defined as immediate hemostasis, was achieved in all 15 treatments during and after the procedure (p=1.0). No significant association was found between the embolization paradigms (deconstructive vs. reconstructive) and the development of complications, as determined by a chi-square test of independence X^2 (2, N=15) =0.07, p=0.79. Additionally, the chi-square statistic with Yates correction was 0.16, with a p-value of 0.69, not reaching significance at $p<0.05$.

DISCUSSION

CBO is notably linked with head and neck cancers, presenting high rates of mortality and morbidity, averaging around

Table 1. Patient characteristics

Age	Sex	Pathology	Prior Treatment	Angiography	Endovascular treatment	Complication
20	M	Nasal Fibrosarcoma	Surgery+RT	ICA irregularity MMA pseudoaneurysm	Hydrocoils Hydrocoils+Glue	Rebleed AF
64	M	NPC	CRT	ICA occlusion	Spontaneous	Exitus
35	F	NPC	CRT	ICA occlusion	Spontaneous	-
49	M	NPC	CRT	ICA pseudoaneurysm	Hydrocoils	-
59	M	NPC	CRT	LA pseudoaneurysm	Hydrocoils	-
47	M	Cystic adenoid ca	Surgery+RT	ICA occlusion	Spontaneous	-
51	M	NPC	CRT	ICA pseudoaneurysm	Covered stent	TIA
45	M	NPC	CRT	ICA pseudoaneurysm	Covered stent	-
58	M	NPC	CRT	ICA irregularity	Vascular plug	-
36	F	Osephagus ca	RT	ICA pseudoaneurysm	Covered stent	-
66	M	NPC	CRT	ICA pseudoaneurysm	Covered stent	-
50	M	NPC	CRT	IMA pseudoaneurysm	Glue	-
66	M	Larynx ca	CRT	ICA pseudoaneurysm	Covered stent	-
55	M	Unknown primary	Surgery+RT	ICA irregularity	Vascular plug	-
47	F	NPC	CRT	ICA pseudoaneurysm	Balloon	-
54	M	NPC	CRT	IMA irregularity	Glue	-
63	M	NPC	CRT	ICA pseudoaneurysm	Covered stent	-

RT radiotherapy, NPC nasopharynx cancer, CRT chemoradiotherapy, ca cancer, ICA internal carotid artery, MMA middle meningeal artery, IMA internal maxillary artery, AF amaurosis fugax, TIA transient ischemic attack.

60% and 40% respectively.[5] Patients with a history of neck surgery and radiation treatment for their cancer are at a 7 to 8-fold increased risk of experiencing a CBO.[5,11] Surgical management for these patients presents substantial challenges due to alterations in the surgical field resulting from previous treatments. Despite the promising results shown by endovascular treatments, there is a crucial need for more extensive data to establish a definitive best practice for endovascular techniques.[7,9,11] In our study, no significant differences in complications were observed between the deconstructive and reconstructive endovascular paradigms, all performed by the same group of interventional radiologists.

Our study showcased a 21% overall complication rate, aligning with figures found in existing literature.[9,11-13] Suarez et al.[9] conducted a recent review indicating an average stroke complication rate of 8% for covered stents and 12% for embolization procedures. However, only two studies out of 28 provided balanced and substantial data on both embolization and covered stent procedures, offering results more aligned with our study.[14,15] Liang et al.[15] reported a complication and rebleeding rate of 24%, half of which were strokes. Excluding late recurrent bleeding from our study, our corrected complication rate would be 13%. Chang et al.[14] presented a wide variety of CBO cases, with their data showcasing a 2.5% overall technical complication rate for the ECA embolization group versus a 50% rate for the ICA covered stent group.

Chaloupka et al.[5] defined recurrent CBO as either a sentinel hemorrhage or an acute CBO occurring within 12 hours of previous carotid blowout syndrome treatment, or any case where an exposed carotid artery manifested at any time post-treatment. In our study, recurrent bleeding from the ECA occurred four weeks after a deconstructive ICA occlusion, situated within the same field as the prior radiation therapy and necrosis. This suggests that the middle meningeal artery branch, made vulnerable by the prior treatments, could have been susceptible to expansion and rupture due to a hemodynamic overload (Figure 3 a,b).

Balloon Test Occlusion (BTO) has been proposed as a method to guide deconstructive treatment decisions, with up to 20% of patients undergoing ICA occlusion experiencing immediate or delayed cerebral ischemia as a result of CBO.[5] However, even among patients who pass the BTO, up to 20% still develop hemodynamic ischemia after permanent carotid artery occlusion.[16] The hemodynamic responses post-bleeding and post-deconstructive embolization can be more complex than initially anticipated.[17] In our deconstructive treatment group, only one temporary hemodynamic neurologic complication was observed following ipsilateral ICA and ECA occlusion one month apart.

While reconstructive endovascular management using a stent graft may seem rational, it could be less favorable in patients with significant surgical wounds, flap necrosis, wound infections, fistulas, and those undergoing ongoing chemoradiotherapy.[16] Chang et al. reported multiple complications in

Figure 3. A 20-year-old male with fibrosarcoma, presenting with re-bleeding four weeks after undergoing internal carotid artery embolization. (a) DSA in AP projection displayed a middle meningeal artery pseudoaneurysm that was not visible during the initial angiogram. (b) The combination of hydrocoil and glue resulted in total embolization and successful treatment of the pseudoaneurysm.

their series, including acute stroke in three patients, carotid thrombosis in three patients, and a brain abscess secondary to stent infection in one patient.[18] Furthermore, some authors have reported a higher risk of CBO recurrence due to stent graft placement compared to embolization therapy or surgical ligation.[7,9] In our covered stent group, we observed one temporary complication, likely due to emboli, with no recurrent bleeding.

Another pattern of arterial injury attributable to radiotherapy, aside from arterial disruption, is arterial occlusion.[19] In our study, three patients presenting with acute CBO had spontaneous ICA occlusions. One patient died due to rebleeding just before transfer, while the other two were monitored in the ICU, with follow-up angiography confirming total occlusion without recanalization, negating the need for further treatment. Optimal treatment approaches should be designed considering the clinical presentation, imaging findings, and urgency of the situation. CBO presentation might be insidious and delayed, potentially occurring decades after radiotherapy, and could recur even after endovascular treatments.[14,16]

However, the major limitations of our study include the small patient population and low sample size, which could contribute to reproducibility issues. The retrospective nature of our study, necessitated by the emergency nature of the pathology, resulted in heterogeneous data similar to that found in existing literature.[20] In our study, the deconstructive group included four ECA CBO cases, while the reconstructive group solely included ICA CBO cases.

CONCLUSION

Recent advancements in endovascular treatments have shown encouraging outcomes in managing acute, life-threatening cases of CBO. Our study, which compared deconstructive and reconstructive endovascular approaches in CBO, aligns with previous research, demonstrating no significant difference in effectiveness between the two paradigms. However, it is important to acknowledge that the literature on this topic remains varied and limited, with a pressing need for more extensive, high-quality studies to strengthen the level of evidence available.

Given these circumstances, it becomes crucial to adopt a highly personalized and careful approach when selecting endovascular treatments for CBO. Every case should be meticulously evaluated on an individual basis, taking into account the unique clinical characteristics and requirements of the patient. This tailored strategy ensures that the chosen intervention maximizes the chances of a successful outcome while minimizing potential risks and complications.

By continuing to refine and personalize endovascular interventions for CBO, and by contributing to the growing body of research on this topic, we can improve patient outcomes and further establish the role of endovascular treatments in managing this complex and life-threatening condition.

Ethics Committee Approval: This study was approved by the Private Anadolu Health Center Ethics Committee (Date: 29.03.2023, Decision No: ASM-EK-23/212).

Peer-review: Externally peer-reviewed.

Authorship Contributions: Concept: M.D.; Design: M.D.; Supervision: M.D.; Resource: M.D., A.Y.; Materials: M.D., A.Y.; Data collection and/or processing: M.D., A.Y.; Analysis and/or interpretation: M.D.; Literature search: M.D.; Writing: M.D.; Critical review: M.D., A.Y.

Conflict of Interest: None declared.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Akut karotis patlamasında dekonstrüktif ve rekonstrüktif endovasküler tedavi paradigmaları

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AMAÇ: Karotis arteri yırtılmasıyla ortaya çıkan nöroonkolojik acil bir durum olan karotis patlaması (KP), esas olarak ışınlanmış baş ve boyun kanseri hastalarında rapor edilmiştir. Bu çalışmada bu olgularda dekonstrüktif ve rekonstrüktif endovasküler tedavi deneyimimizi sunmayı amaçladık.

GEREÇ VE YÖNTEM: 2003 ile 2022 yılları arasında kulak, ağız veya burun kanaması ile başvuran ve konservatif tedavilere yanıt vermeyen akut KP'lı 17 hasta çalışmaya dahil edildi. Dekonstrüktif embolizasyon vasküler tıkaçlar, genişleyen hidrojel sarmallar, yapıştırıcı ve balon kullanılarak yapıldı. Eğer damar anatomisi ve patolojisi uygunsa kapalı stent ile rekonstrüktif tedaviyi tercih ettik. İşlemlerin klinik başarısını değerlendirmek için tüm hastalar klinik ziyaretler ve modifiye Rankin skalası ile takip edildi. Dekonstrüktif ve rekonstrüktif tedavi yöntemlerinde komplikasyon sonuçları ki-kare testi ile karşılaştırıldı.

BULGULAR: Hastaların yaş ortalaması 20-64 (ortalama 50.9) olup, üçü kadın (%18), 14'ü (%82) erkekti. 19 anjiyografi sırasında 14 hastaya 15 endovasküler işlem uyguladık. 15 tedavinin tümünde anında hemostaz ve tam teknik başarı sapşandı (p=1.0). Hastaların altısına (%35) internal karotis arterde kaplı stent kullanılarak rekonstrüktif tedavi uygulanırken, dokuzuna eksternal karotis arter veya internal karotis arterde (%65) dekonstrüktif embolizasyon uygulandı. Tedavi paradigmaları (dekonstrüktif vs. rekonstrüktif) ile komplikasyon gelişimi arasında ki-kare bağımsızlık testi kullanılarak anlamlı bir ilişki saptanmadı X^2 (2, N=15) = 0.07, p=0.79.

SONUÇ: Son yıllarda ortaya çıkan endovasküler tedaviler, hayatı tehdit eden akut KP vakalarında umut verici sonuçlar ortaya koymaktadır. Çalışmamız bu hastalarda uygulanan dekonstrüktif ve rekonstrüktif endovasküler paradigmalar arasında anlamlı bir fark bulmadı. Ancak çalışmamızda ve literatürdeki veriler heterojen ve yetersiz olup, kanıt düzeyinin daha yüksek olması gerekmektedir.

Anahtar sözcükler: Embolizasyon; karotis patlaması; karotis yırtılması; kaplı stent; .

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