A MULTIDISCIPLINARY APPROACH TO TREATMENT OF HIGH FLOW HEAD AND NECK ARTERIOVENOUS MALFORMATIONS: SINGLE CENTRE EXPERIENCE IN 7 COMPLEX CASES

Saima Ahmad[*1], Roomana Akhlaque[2], Moeez Uddin[3], Umair Rashid[1], Anchalee Churojana[4], Muhammad Aslam Khan[1]

[1]Department of Neuroradiology, Lahore General Hospital, Lahore, Pakistan
[2]Department of Burn and Reconstructive Surgery, Lahore General Hospital, Lahore, Pakistan
[3]Manchester University NHS Foundation Trust, Manchester, United Kingdom
[4]Department of Diagnostic Radiology, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand

***Corresponding author:**
Saima Ahmad, Department of Neuroradiology, Lahore General Hospital, Lahore, Pakistan. Email: masterinfluencer@gmail.com

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ABSTRACT

Introduction: The objective of this work is to determine the role of a multidisciplinary approach in treating the complex high flow head and neck arteriovenous malformations (AVMs), involving radiologists and plastic surgeons for the best possible outcomes.

Methods: Between 2018 and 2020, the investigators conducted a retrospective analysis on seven patients with high-flow head and neck AVMs who received treatment at a tertiary care facility. Age at first diagnosis, presenting features, prior therapies, endovascular treatment, surgical treatment, and therapeutic outcomes were all recorded. A comparison of pre-and post-procedure pictures was made to assess the clinical outcomes for all patients.

Results: Seven patients with complex high flow head and neck AVMs were jointly managed by performing plastic surgery and interventional radiology. There were male and female, with an average age of 24 years. Each patient underwent embolization followed by surgical resection within a 24-hour window of up to 72 hours. In six out of seven patients, the lesion was removed therapeutically, whereas the seventh required palliative resection. Only one patient, there was a minor wound healing difficulty able to be treated with dressings.

Conclusion: The results revealed that embolization alone is not effective to reduce the adverse effects. Incomplete removal of AVM showed the same effect as incomplete removal of a tumour. It may not improve symptoms and may worsen the recurrence, thus multi-modality approach is beneficial. A multidisciplinary approach, aided by the interventional radiologist and enable plastic surgeons to remove the high-flow AVMs effectively.

Keywords: Arteriovenous malformation; Embolization; High flow; Multidisciplinary; Plastic surgery

ABBREVIATIONS

AVM: Arteriovenous Malformation
AP: Antero-posterior
CT: Computed Tomography
DSA: Digital Subtraction Angiography
DSMO: Dimethyl Sulfoxide
ECA: External Carotid Artery
EJV: External Jugular Vein

EVT: Endovascular Therapy
H&N: Head and Neck
ICA: Internal Carotid Artery
ISSVA: International Society for the Study of Vascular Anomalies
MRI: Magnetic Resonant Imaging
MDM: Multidisciplinary Meeting
NBCA: N Butyl Cyanoacrylate
OA: Occipital Artery
PAA: Posterior Auricular Artery
PVA: Polyvinyl Alcohol Particles
PAV: Posterior Auricular Vein
STA: Superficial Temporal Artery
VA: Vertebral Artery

INTRODUCTION

Head and neck AVMS, according to the International Society for the Study of Vascular Anomalies (ISSVA), are high-flow vascular malformations that are rare and thought to be congenital. (1) Trauma frequently discloses dormant AVMs. Curative surgical treatment results in the best outcome if treated in the early stage of the disease, and the advanced stage for conservative treatment remains the only viable option in most cases. (2) However, surgical options are still feasible in advanced, diffuse lesions.

Surgical approaches are associated with a greater morbidity rate and a strong probability of recurrence, especially diffuse lesion. (2) Despite surgical excision and 98% embolization, 81% of peripheral AVM patients recurred based on a study of 272 individuals with head and neck AVMs. Nidus leftovers were a significant component in recurrence, and their complicated morphology and considerable vascular collateralization were frequently implicated. (3) Thus, complete removal of the nidus is of utmost importance, either radical surgical resection or ablation.

This radical approach may include normal structures in numerous tissue planes, with the potential for deformity and functional impairment (3). A single therapeutic modality is unlikely to result in a significant long-term improvement, hence, a multimodal treatment plan is likely to give a better result (4).

The ideal way to treat head and neck AVMs is with a multidisciplinary strategy that includes endovascular embolization as well as surgical excision. However, due to the infrequent cases, current experience is limited to tiny case series and isolated incident reports.

This review of 7 cases highlights the short and medium-term treatment outcomes from a multidisciplinary approach for the case of complex head and neck AVMs, from a single centre.

METHODS

All patients with high flow complex head and neck AVMs were confirmed diagnosis based on angiography. For this case study, a multidisciplinary team was made up of plastic surgeons, neuroradiologists, and neurosurgeons. They evaluated all of the patients' clinical and imaging records and agreed with the diagnosis of AVM.

All of the patients had digital subtraction angiography with selective opacification of both ICAs and ECAs in AP and lateral projections emphasized on the head and neck region. In all cases, endovascular therapy was performed. The multidisciplinary team reviewed the donor site healing in terms of flap survival and graft. In selected cases, a follow-up CT angiogram or MRI was performed in order to have a more detailed assessment. Informed consent was obtained for all cases to acquire both photographs of pre-procedure and post-procedure.

RESULTS

In all seven patients, five females and two maleswith the age ranges from 16 to 28 years old. Of all patients, the endovascular treatments were performed within 24 to 72 hours prior to surgery. In cases that underwent multistage embolization, excision was performed after the last embolization session. Four out of all patients, immediate post-embolization angiography revealed the full angiographic exclusion of the AVM.

AVMs were found on the scalp and forehead in four of the patients; the pinna and postauricular region were found in the first case, and the pinna and scalp were noticed in the seventh case. Transarterial embolization was performed on six patients, while one patient was treated percutaneously via direct puncture. Co-polymer embolic materials (Squid 18) were used in three cases, while n-BCA was used in the other four.

Four out of seven patients had previous surgery, while one of the patients had underwent two surgical procedures and another two patients never had any prior treatment. None had any experience with the endovascular procedure. In all cases, follow-up was done for a period of 1 to 3 years. Patients were

monitored clinically based on the multidisciplinary team's clinical assessment and subjective experiences. There were no recurrences or persistence of symptoms in all seven cases after 3 years of follow-up. Six patients were cured and one had satisfactory results. One patient experienced minor local pain at the AVM site, which was relieved with painkillers.

Endovascular Technique

In all cases, we choose the right femoral artery approach with a 6 Fr femoral sheath and a 6 Fr guiding catheter. Microcatheters were selected based on the difficulty of nidal access and embolic material preferences. For copolymer embolic materials of Squid 18 was used for the approach of injection of plug and push under intermittent fluoroscopy, whereas n-BCA was used for the flow-aided approach. The microcatheter was primed with a 5% dextrose solution for n-BCA, and the n-BCA: lipiodol dilution ranged from 1:1 (50 per cent dilution) to 1:5 (16 per cent dilution). Using the same method, different feeders were embolized independently. In the direct percutaneous approach, the lesion was directly punctured with a 16-gauge cannula under roadmap guidance. Temporary occlusion was performed by using the cookie-cutter technique and the diluted n-BCA with lipiodol was injected into the venous pouch.

Both kinds of microcatheters (detachable tip and non-detachable tip) can be used for glue embolization. Usually, the glue is mixed together with an oily contrast agent (ethiodol) that prolongs the polymerization time, increases viscosity, and makes the mixture radiopaque. The ratio of glue to oil can be changed and generally ranges from 1:1 up to 5:1, and the dilution of glue depends on the amount of oil. The ratio is changed depending on the flow characteristics of the AVM. The mixture of oil and n-BCA is comparatively unstable and often hardens spontaneously after 15 minutes. Therefore, the microcatheter must be rinsed with 5% dextrose in a water solution before injecting an amount of glue. The glue is introduced using the push technique and the microcatheter is placed in the wedge position close to the nidus. Care should be taken to preserve the main vascular trunk leading to the malformation as subsequent treatment will likely be required. A control angiogram is always obtained to verify the complete closure of the nidus.

In a single patient, a direct percutaneous approach was chosen for embolization because a ligitation of the external carotid artery ligation was performed during a previous surgery and navigation to the nidus was difficult. After selective transarterial angiogram, the lesion was punctured directly with a 16-gage cannula under roadmap guidance. Temporary occlusion was achieved by using the cookie-cutter technique and a mixture of glue and lipiodol administered in a venous pouch. Angiogram after embolization angiogram showed complete occlusion of the scalp AVM. In arteriovenous malformations of the head and neck, ICA feeders were not able to embolize them to avoid neurological complications (**Figure 1**).

Surgical Technique

Surgery was performed in all seven patients within 24 to 72 hours after superselective embolization. All cases underwent elective surgery after the necessary optimization. Blood grouping and crossmatching were performed in all patients. After intubation, patients were placed in the supine, prone, or lateral position, depending on the location of the AVM, with the head end elevated 30 degrees above the level of the heart. In all seven patients, an attempt was made to remove the entire AVM including the overlying skin and subcutaneous tissue, to reduce the recurrence. Therefore, it should be noted that the primary closure was achieved in one patient during the study, while a cross-linked split-thickness skin graft was used for resurfacing in the other five patients, and a temporoparietal fascia flap with cross-linked split-thickness skin graft that was used in another patient. In all patients, a conforming dressing was applied and the head was elevated after surgery and closely monitored for rebleeding. Two patients with primary closure and flap plus graft had suction drainage. The first postoperative dressing was changed on the fifth day, followed by new dressings every three days. The staples placed over the skin graft were removed on the eighth postoperative day.

Illustrative Cases

Case 1

A 16-year-old female patient presented with a pulsatile, boggy swelling of the left auricle and scalp that gradually increased in size. History included headache, tinnitus, and recurrent bleeding from minor trauma, which was controlled by local pressure and dressings. Clinical examination revealed that the swelling

involved the entire left auricle and postauricular area, as well as the left temporoparietal, vertex, and occipital scalp regions. The swelling was pulsatile and diffusely serpiginous, with palpable tingling and audible bruit at multiple sites. It was compressible and regressible with a recovery time of less than one second. The skin was hyperpigmented and hypopigmented, which was due to healed ulcerations. The patient has undergone surgery at a peripheral hospital 6 years ago. The scar from the previous surgery was visible on the left side of the neck, and the surgical notes showed ligation of the left external carotid artery. However, the patient noted a rapid increase in swelling after surgery.

An angiographic examination was performed before deciding on the final treatment plan. DSA showed a fistulous auricular AVM fed by the left posterior auricular artery and the muscular branch of the right vertebral artery draining into the external jugular vein. The left vertebral artery was ligated at the previous operation. The AVM of the scalp was fed by the OA and STA from the right carotid system and drained into the right parieto-occipital vein ecstata. A staged treatment was planned to keep in mind the size of the scalp AVM (occupying nearly two-thirds of the scalp) and two anatomic structures are commonly known as the scalp and auricle. Pre-surgical embolization of the scalp AVM was decided as the first step, followed by surgical excision within 72 hours. After angiography, the dilated venous sac of the scalp AVM was accessed percutaneously with a 16-G cannula under roadmap guidance by injection into the external carotid artery. The cannula dead space was injected with 10% dextrose water and the vein was sealed with glue (50% concentration). Temporary flow arrest was achieved by manual cookie-cutter compression (**Figure 2** and **Figure 3**).

Embolization was observed within 72 hours after embolization. Actually, proximal vascular control of the ipsilateral external carotid artery should be performed to avoid bleeding catastrophe, but this is not possible due to prior ligation of the ECA in some peripheral hospitals. The patient was placed in the prone position with the head elevated after endotracheal intubation. An inert S-shaped incision was made that encompassed the AVM of the scalp and extended vertically into the left preauricular region. Numerous large, tortuous, dilated, thin-walled fragile vessels were encountered, clipped and divided distally, followed by dissection in the subcallosal plane. Ipsilateral and contralateral occipital vessels, as well as ipsilateral STA, were transected after the application of Lega clips. Nearly two-thirds of the affected scalp AVM was excised, and the wound was closed by applying the mesh-like split-thickness skin graft. The patient recovered postoperatively without problems, except for minor wound healing problems and was treated with topical ointments and dressings.

Case 2

A 28-year-old man presented to our institution with a pulsatile swelling on the right forehead that has been present since childhood. The history included headache, palpitations, and pulsatile swelling of the periorbital vessels as well as redness of the right eye and periorbital region with visual disturbance. Clinical examination revealed a 15 cm × 8 cm × 4.5 cm oval swelling in the right frontal half with visible pulsations and audible bruit. There were multiple hypopigmented scars over the swelling. There were markedly dilated tortuous frontal branches on both sides from STA, which also had visible pulsations. The angiogram showed a hypertrophied right STA with gross dilatation and tortuous course of its frontal branch draining into the nidus along its entire length. The draining superficial scalp veins were also markedly dilated. Injection into the right internal carotid artery revealed additional supply from the supratrochlear and supraorbital branches of the right OA. Embolization via transarterial route was performed before surgery and the frontal branch of STA was embolized with glue. Feeds from the OA were not attempted for fear of reflux (**Figure 4**).

It was noted that the resection and reconstruction occurred within 24 hours after embolization. The patient was placed in the supine position with the head elevated. The frontal branches STA on both sides were ligated and transected as proximally as possible. Along the right edge of the AVM, a C-shaped incision with an upper extension of 4 cm was made in the scalp to expose and ligate of the one large feeder vessel. Complete excision of the AVM was performed with excision of the skin ellipse. Layered wound closure was performed over a suction drain, which was removed after 48 hours. The skin staples were removed on the tenth postoperative day. The patient recovered without complications.

Case 3

A 38-year-old man presented with pulsatile swelling of the entire right ear and a gradual increase in size of the right ear (macrotia). There was a history of haemorrhage from minor trauma, which was treated by local compression. Clinically, the malformation involved the entire external ear and extended from the root of the spiral rim to the earlobe and

postauricular region with discolouration of the overlying skin. The swelling was compressible and resolved in less than two seconds. Tingling was easily palpable and a continuous bruit was heard on auscultation. The external auditory canal and tympanic membrane were unremarkable. The clinical diagnosis of high-flow arteriovenous malformation was made on the basis of history and examination by a multidisciplinary team.

Angiography revealed a high-flow AVM in the auricle, draining into the right PAA and OA, and draining into PAV and EJV. However, additional supply through the internal carotid system was not detected. At the same time, preoperative embolization was decided to reduce vascularity before surgical excision. Transarterial embolization was performed by PAA with 70 % glue, and almost 75% of the AVM were embolized. Surgery was scheduled 48 hours after embolization.

The patient was placed in the supine position with the head turned to the left side. Ipsilateral proximal control of the ECA was taken. The incision was made in the postauricular region and the posterior auricular artery was ligated and divided. The entire lesion on the posterior side was resected along with the skin, subcutaneous tissue, and perichondrium, preserving the cartilage of the auricle. The malformation in the concha was excised via the anterior approach. The length of the spiral rim was reduced by a wedge excision, and the width of the ear was reduced by several small triangular excisions. Resurfacing of the exposed auricular cartilage was performed with an ipsilateral temporoparietal fascial flap and a split-thickness skin graft from the thigh. A suction drain was placed in the postauricular area and then a conforming dressing was applied (**Figure 5**)

DISCUSSION

Arteriovenous malformations are known to be vascular anomalies with high-flow and numerous low-resistance shunts that short-circuit the capillary bed. It enlarges not by cellular hyperplasia but by hemodynamic mechanisms. As a result, collateral formation is promoted, which in turn diverts regional blood flow from the periphery (4).

Arteriovenous malformations in the head and neck are much less common than intracranial AVMs. Rapid blood flow typically becomes evident in childhood. Puberty or trauma appears to trigger the expansion. Treatment of these lesions is based on clinical symptoms, which may vary depending on type, size, and location. Usually, they are cosmetic problems, pain, bleeding, or ulceration. Selective angiography is better suited to characterize the nidus, flow pattern, and micro- or macro-arteriovenous fistula before interventional therapy (5). Treatment of arteriovenous anomalies is generally known to be potentially dangerous, and sometimes the results are disappointing (4).

The therapeutic strategy consists of selective embolization combined with surgical ablation and reconstruction. The goal of preoperative embolization is primarily to reduce blood loss and facilitate surgical extirpation. It should be noted that the extent of resection should be reduced in this disease. Surgical excision should not be delayed for more than 72 hours after embolization, as the inflammatory process complicates surgical access, thus negating any hemostatic benefit (4).

Neither surgery nor embolization alone is the correct treatment. For this purpose, AVMs, in particular, must be ligated or proximal embolization of the feeding arteries must never be performed. Rapid recruitment of flow from the normal anastomosis of the head and neck region will then supply the nidus so that proximal arterial blockage will deny access for embolization. (5) All these limitations occurred in case No. 1, where proximal ligation of the ipsilateral ECA resulted in rapid recruitment of flow from the contralateral ECA. It is possible to take the proximal vessel control in the neck, which could have contributed to a reduction in operative time and blood loss.

Surgical ligation has been performed for decades as the only treatment modality for these lesions. However, proximal surgical ligation of the feeding arteries without resection is doomed to failure because it may exacerbate the condition by promoting the collateral formation and also removes a potential access channel for therapeutic embolization (4).

Scalp AVM should be excised largely to the pericranium, with primary closure of the defect by either skin grafting or scalp flaps. Simple capillary staining of the auricle may be the first warning sign of underlying AVM. Complete amputation of the ear and, if necessary, transection of the VII cranial nerve may be required. If excision is not completed in a timely manner, the AVM will re-expand and may encircle the skin graft or skin flap used for the reconstruction (4).

Endovascular therapy alone is not a treatment of choice to recommend such an event. H&N AVMs have such complex architecture and abundant natural arterial supply lesions on the face and scalp that treatment plans can become complicated. Therefore, a midline lesion is often supplied by bilateral external carotid arteries (ECAs) and usually has multiple draining veins. The development of microcatheter techniques has allowed the delivery of NBCA, PVA, and other embolic agents into the AVM nidus (6).

We have a multidisciplinary team at our institution that makes decision about vascular malformations of the head and neck. We have divided small H&N AVMs into two groups: those curable by embolization and those curable by surgical excision after embolization. Large AVMs are divided into two groups: either they can be cured by post-embolic excision or not. The latter group was treated with

embolization only for symptomatic relief. Our approach is summarized in **Table 1** (6).

A critical role of endovascular embolization in H&N AVMs is a palliative treatment for symptomatic relief and supportive treatment before surgical excision. This is especially true when larger malformations are involved. Embolization is the treatment of choice to control acute haemorrhagic events and is performed urgently as soon as the incident occurs. Ideally, surgery should be performed within 72 hours of embolization in order to minimize the risk of developing collateral supply and inflammation-related complications. This may be supported by the fact that excision must include the embolic material and thus the overall workup does not reduce the effective lesion size.

In H&N AVMs that have a large number of recruiting vessels that are not connected to the nidus (angiogenesis), care must be taken during embolization. Consequently, embolization must be performed directly on the nidus of the lesion without targeting the supplying arteries or collaterals, unless surgery is planned immediately thereafter. Therefore, anagenesis is unlikely with therapy directed to the nidus. Experience has shown that anagenesis is far more common in large AVMs where the nidus is more difficult to access. Anagenesis is normal even with incorrect management with proximal ligation.

Proximal ligation should not be performed if a patient has received proximal ligation before referral to us. In the case of our series, with two AVMs on the scalp and auricle, surgical ligation of the ECA and VA was previously performed. Thus, angiogenesis can occur within weeks to months after improper embolization. It is essential for the development of angiogenesis to involve the previously healthy tissue surrounding the AVM. This can be a serious problem if these vessels are fragile and bleed easily. Angiogenetic arteries are often difficult to reach by endovascular means and therefore, must be reached by surgical access (6).

Complications associated with extra-axial embolization include neurologic defects resulting from reflux of occlusive material into the intra-axial vessels supplying the brain. For example, cranial nerve palsies can be caused by obliteration of small branches of the external carotid artery that supply the peripheral cranial nerves. This can occur but is rare when minimized by the ability of angiography to accurately position the catheter and the incorrect use of embolic agents, and adequate knowledge of the malformation and architecture is a must (4).

At the other end of the spectrum, there are risks and complications that are relatively specific to cyanoacrylate adhesive (n-BCA) embolization. Among the more serious complications is intracerebral haemorrhage. Vascular perforation during microcatheter placement and delayed haemorrhage due to obstruction of venous outflow or increased blood pressure in a residual nidus or feeders are the main causes of such complications. Vascular perforation during microcatheter placement can be very risky and can easily occur by reducing the use of flow-directed microcatheters. The use of a metal guidewire with a flow-guiding catheter for advanced placement and navigation in the feeder of the AVM is a prerequisite for this common occurrence. However, it is important to be careful not to extend the guidewire beyond the catheter tip (8).

Large and diffuse high-flow H&N AVMs are the major obstacle. They are usually treated by transarterial embolization to control acute bleeding; these lesions may require various percutaneous and endovascular approaches. For lesions in the soft tissues of the face and scalp, manual compression of the draining veins at the time of embolic delivery may be beneficial, and the placement of a tourniquet has been shown in our experience to better distribute embolic material into the nidus and proximal draining veins. This tourniquet is left in place until the delivery of the embolic agent, in the case of n-BCA, until it solidifies (6).

Liquid embolic agents are increasingly used to treat AVM in the head and neck region. Thoughtful optimization of flow dynamics for penetration of nidal and AV fistulas during embolization of a dominant arterial branch is believed to be critical to success (7).

Direct puncture embolization is the other method used for preoperative devascularization of superficial craniofacial AVM with prominent venous pouches. It is comparable to the arterial Tans method. It may reduce the likelihood of incomplete embolization and therefore, results in later recruitment of new collateral feeders. Therefore, the effect is more dramatic and immediate, especially in symptom relief and intraoperative bleeding control. For cosmetic reasons, there is no additional risk of necrosis of the skin, the lesion can be resected without grafting. However, it is a definitive treatment when surgical resection is required in patients who do not desire bulging of a superficially palpable adhesive dressing (9).

A combined treatment approach is the right way to treat complex AVMs with high flow in the head and neck region.

Surgical excision with embolization or a combination of the two modalities has been used to treat AVMs. Evidence suggests that surgery with preoperative embolization followed by lesion removal offers the best chance of cure. Be that as it may, recurrent, relapsing, or quiescent lesions cannot be avoided regardless of treatment. It is a common finding regardless of the treatment modality, especially embolization for high blood flow arteriovenous malformations, which initially had a low value but is currently observed to have better outcomes than previously limited procedures. And now the results with embolic agents like Onyx. Close monitoring of malformations as in the treatment of malignancies is therefore necessary (10).

Table 1: Demographics, location, endovascular and surgical treatments of patients with high flow head and neck arteriovenous malformations

Patient	Age (year) /Gender	AVM Localization	Presenting Features	Feeding Arteries	Endovascular Treatment	Previous Surgery	Surgical Treatment	Complications and Follow Up
1	16/F	Pinna (L), scalp	Cosmetic reasons, pain, recurrent haemorrhage , bruit, tinnitis	Auricle AVM-L PAA , R VA (muscular branch) Scalp AVM- R OA , STA Venous drainage-auricle AVM drained into EJV Scalp AVM draining ectatic parieto occipital vein	Percutaneous route embolization of scalp AVM with Glue	1	Total resection of scalp AVM and reconstruction	Flap infection/1.5 years/no recurrence
2	38/M	Pinna (R)	Swelling, recurrent haemorrhage s, ulceration, bruit	R-PAA ,R-OA Venous Drainage - R- PAV, EJV	Transarterial embolization of arterial fedders with Glue	0	Total resection and reconstruction	Nil/1 year/no recurrence
3	35/F	Scalp	Swelling, recurrent haemorrhage , ulceration, pain, bruit	B/L OA ,STA Draining vein-Scalp veins	Transarterial embolization of right OA and STA with Glue	0	Excision and reconstruction	Nil/1.2 years/no recurrence
4	25/F	Pinna (R)	Cosmetic reasons, recuurent bleeding, pain, ulceration	R-PAA Draining vein-PAV & EJV	Transarterial embolization of right PAA with Squid 18	0	Excision and reconstruction	Persistant pain/1.5 years/no recurrence
5	28/M	Forehead	Cosmetic, recurrent episodes of bleeding on minor trauma, ulceration, bruit	Anterior branch of R -STA Supratrochlear and supraorbital branch of R-ICA Drainage vein-superficial scalp veins	Transarterial embolization of right STA with Squid 18	2	Excision and reconstruction	Nil/1 year/no recurrence
6	26/F	Scalp	Cosmetic reasons, bruit, headache, tinnitis	R-OA and R-STA Draining vein-R-Parieto-occipital vein Draining intracranially through emissary veins	Transarterial embolization of R -OA and STA with Squid	1	Total resection and reconstruction	Nil/1.3 years/no recurrence

Patient	Age (year) /Gender	AVM Localization	Presenting Features	Feeding Arteries	Endovascular Treatment	Previous Surgery	Surgical Treatment	Complications and Follow Up
7	35/F	Scalp, forehead	Cosmetic reasons, painful, bruit, right ocular pain	R-Anterior branch STA R-supraorbital and supratroclear branch of OA Draining Vein-Superficial scalp veins	Percuataneous embolization of venous pouch with Glue	1	Total resection and reconstruction	Nil/2 years/no recurrence

There are several evidences in the literature confirming the efficacy of combined treatment as in our case. Most extracranial AVMs require combined treatment, especially when the malformations have an infiltrating component with multiple feeding arteries. Even in these patients, the percentage of complete response (cure) is low and the recurrence rate is high. In our study, all embolization procedures were combined with surgical resection. Complete and partial response rates were relatively similar to those reported in the literature (11).

Other studies continue to conclude that combined treatment is the best approach. Diffuse AVMs are rarely easily curable but can be controlled with this treatment option despite the difficulty in achieving a successful outcome. However, delaying treatment causes the AVM to grow and infiltrate additional normal tissue making treatment less successful and more difficult.

Due to this reason, many doctors (including the author) advised that the early intervention with the treatment of AVMs is supposed to be done before the symptoms develop. This early intervention considers to be a better lesion control and AVMs are never precipitously resolved. The most obvious opportunity for treatment is from the get-go in the phase of the disease as the AVM is yet to progress to a more progressive state. This is when patients experience higher morbidity and treatment is more difficult and less productive. In summation, the management of H&N AVMs needs a multidisciplinary approach and multimodal care must be used by appropriately trained doctors. The treatment needs to be repeated and therapy must be done for disease control. The pace of development, notwithstanding, might be capricious. Improved treatment results and quality of patient satisfaction are vital and worldwide research is done on the subject to find better more solid medical choices for treatment in the hopes of finding a cure (12).

CONCLUSION

The results revealed that embolization alone is not effective to reduce the adverse effects. Incomplete removal of AVM showed the same effect as incomplete removal of a tumour. It may not improve symptoms and may worsen the recurrence, thus multi-modality approach is beneficial. A multidisciplinary approach, aided by the interventional radiologist and enable plastic surgeons to remove the high-flow AVMs effectively.

STATEMENT OF ETHICS

Written informed consent was obtained from the patients for publication of the cases and accompanying images shown in this work.

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CONFLICT OF INTEREST

The author(s) declare that they do not have any potential conflicts of interest concerning the research, authorship, and/or publication of this article with anyone.

DATA AVAILABILITY STATEMENT

The data used in this work can be requested from the corresponding author upon reasonable request.

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FIGURE LEGENDS

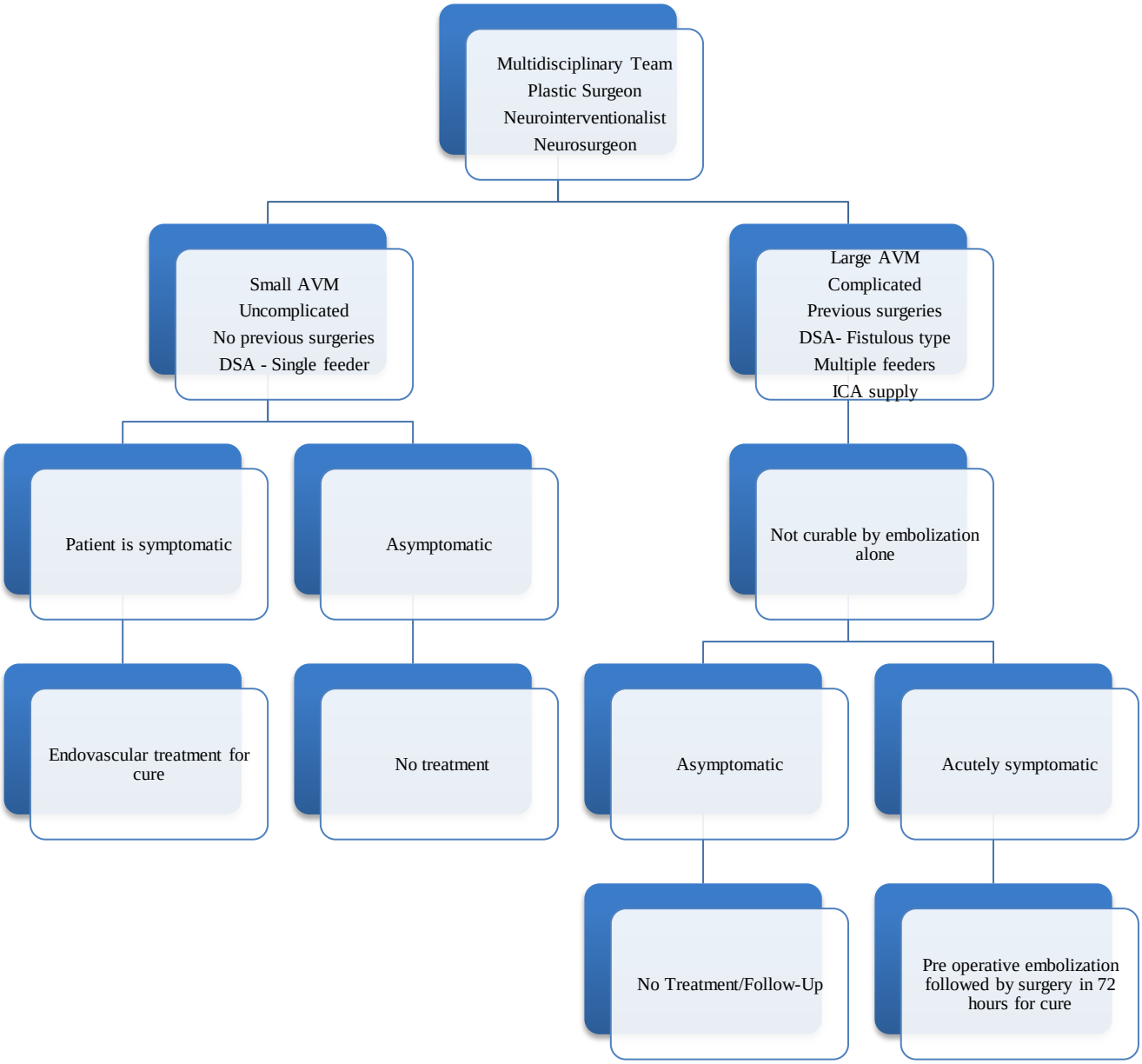

Figure 1: Schematic flow chart describing the management of H&N AVM

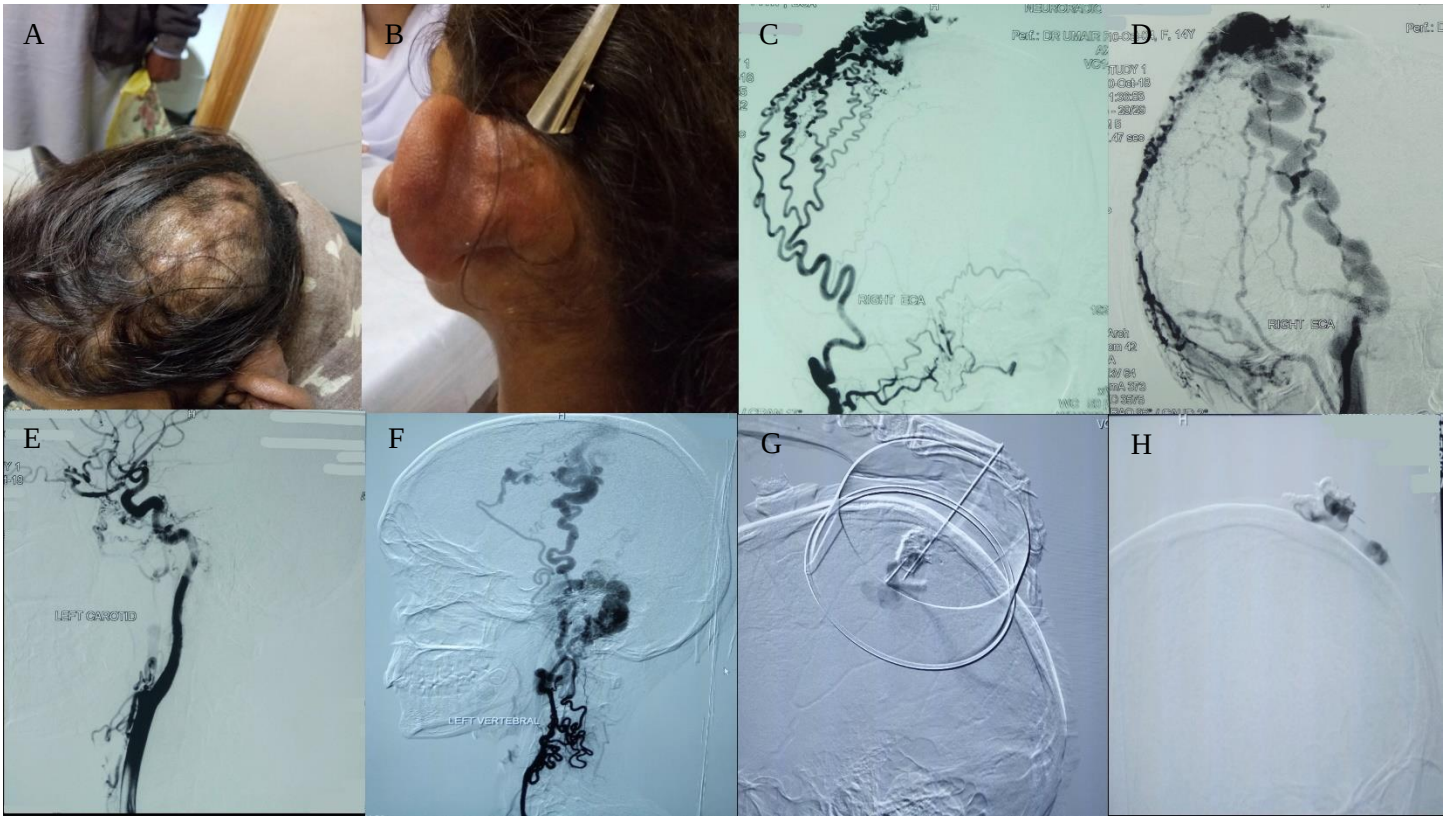

Figure 2: Case 1: (A, B) Pre-procedure photograph of a 16-year-old girl presented with double swellings – Scalp and pinna since childhood. (C, D, E, F) Right ECA angiogram, lateral projection, showing scalp AVM supplied by branches of the occipital artery. The draining vein was the dilated scalp vein.Left CCA angiogram, lateral projection, revealed ligated stump of the left external carotid artery. Left VA angiogram, lateral projection, showing auricular AVM, supplied by muscular branches of vertebral artery and contralateral external carotid artery. (G, H) Direct puncture of the nidus and glue embolization was performed with a 21 gauge butterfly needle with the occlusion of venous outflow.

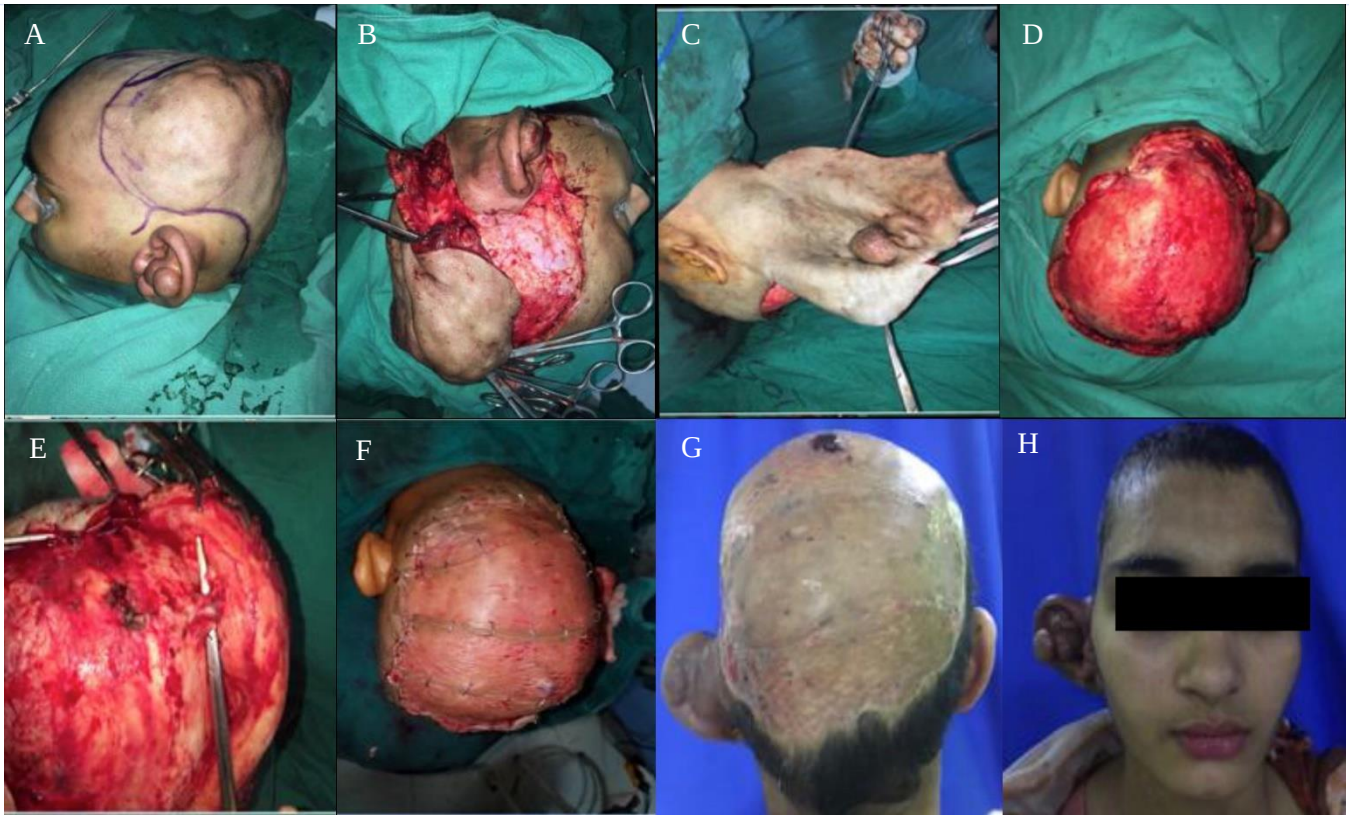

Figure 3: Case 1: (A, B, C, D, E) Embolization was followed by resection and reconstruction. An inert S-shaped incision was made that encompassed the AVM of the scalp and extended vertically into the left preauricular region. (G, H) Postoperative results.

Figure 4: Case 2: (A) A 28-year-old man presented with a pulsating swelling in the right forehead since childhood. (B) Lateral angiogram of right ECA revealed hypertrophied STA with gross dilatation and tortuous course of its frontal branch along its entire length draining into nidus. Additional supply from the right ICA was also present (not shown). (C, D, E, F, G, H) Embolization was followed by resection and reconstruction occurred within 24 hours after embolization. Along the right edge of the AVM, a C-shaped incision with an upper extension of 4 cm was made in the scalp to expose and ligate one large feeder vessel. (I, J) Postoperative photograph.

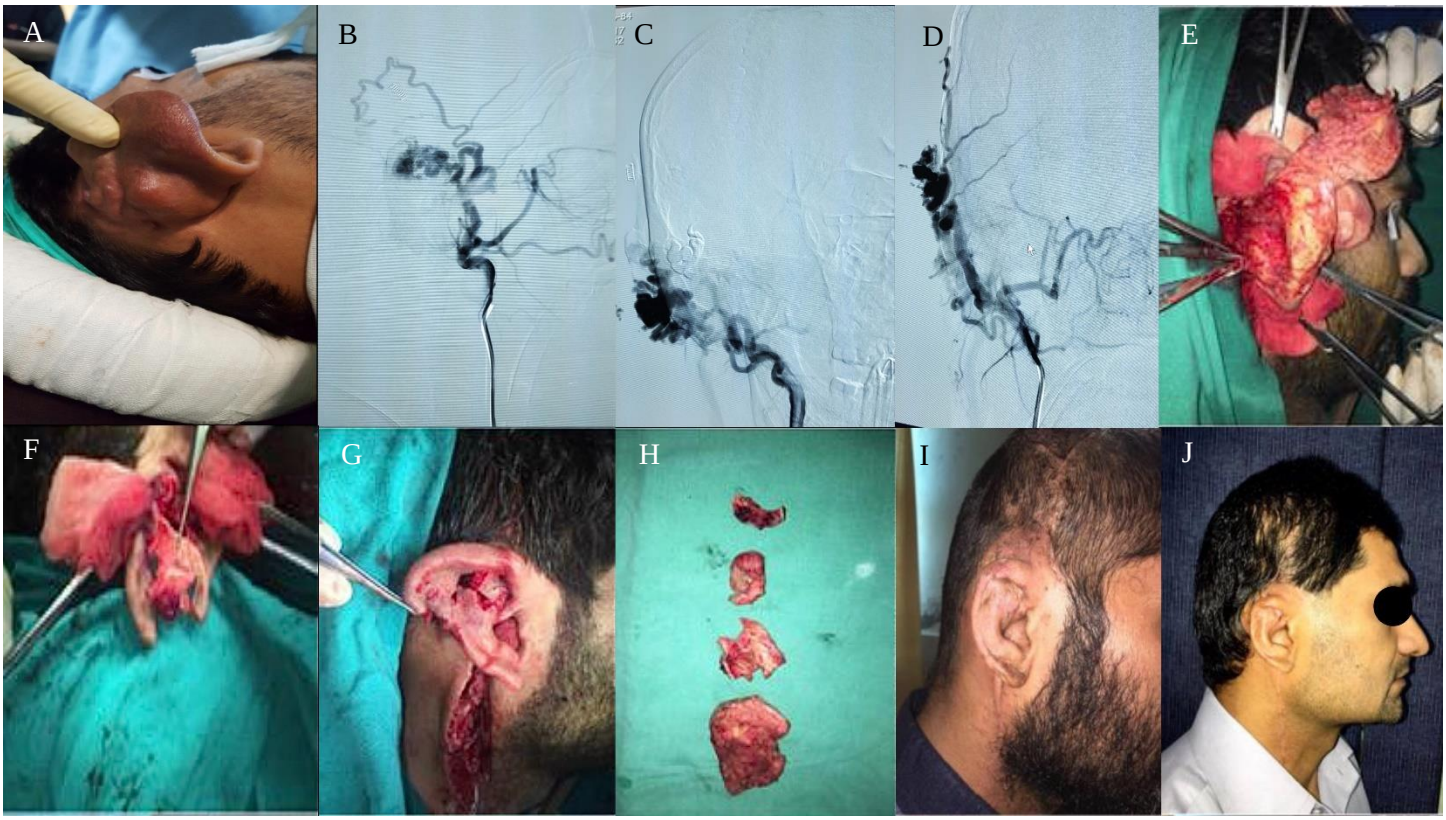

Figure 5: Case 3: (A) Lateral view of a 35-year man presented with right ear pulsating mass, redness, and swelling. (B) Lateral angiogram of the right external carotid artery (C, D) Transarterial embolization was performed with glue after selective catheterization of the posterior auricular artery. (E, F, G, H) The malformation was excised through the anterior approach, and resurfacing of the exposed auricular cartilage was performed with an ipsilateral temporoparietal fascial flap and a split-thickness skin graft from the thigh. (I, J) Postoperative and follow-up photographs.