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Evaluation of preoperative endovascular embolization of highly vascular brain tumors; impact on surgical outcome and complications

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Abstract

Assessment of the impacts of preoperative transarterial embolization (TAE) on the surgical outcomes of patients undergoing resection of highly vascular intracranial tumors. 28 patients received TAE using polyvinyl alcohol (PVA) particles, Gelfoam or ethylene vinyl alcohol copolymer (Onyx). Preoperative ventriculo-peritoneal (VP) shunt was inserted for patients had high intracranial pressure or posterior fossa SOLs. The appropriate neurosurgical procedure was performed according to the SOL location. Success of embolization procedure was evaluated intraoperatively as the extent of lesion devascularization and the maximal resection feasibility. Slight hemiparesis in one patient and insertion site minor complications in three patients were the reported TAE complications. Embolization using PVA, Onyx and Gel-Foam was applied for 13, 10 and 6 procedures, respectively. Three patients required postoperative VP shunt. Lesion devascularization was good, fair and poor in 24, 3 and 2 patients, respectively. Demarcated cleavage line was well-evident in 22, while was fair in 5 and poor in two cases. Dissection and debulking of the lesion was easy in 22, fair in 4 and difficult in 3 cases. Six patients (20.7%) required blood transfusion. Mean duration of ICU stay was 28.8±5.9 hours and mean hospital stay was 2.4±0.7 days. TAE of highly vascular intracranial tumors is an effective preoperative strategy to facilitate surgical excision within acceptable operative time and good lesion debulking and spared blood transfusion. TAE using onyx or PVA provide satisfactory tumor devascularization and well-define line of tumor demarcation.

Keywords: Intracranial tumors, Transarterial embolization, Lesion devascularization.

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1. Introduction

Intracranial meningiomas are the most common primary brain tumor in adults that originate from the meningothelial cells of the arachnoid mater and are mostly benign, WHO Grade I neoplasms [1]. However, atypical and anaplastic meningiomas are considered malignant lesions and are at increased risk of recurrence after maximum safe surgical resection [2]. Further, despite being benign, meningiomas are surgically challenging lesion for being hypervascular or located in skull base [3]. Hemangioblastomas (HGBs) are highly vascular benign tumors that represent 2-3% of central nervous system (CNS) tumors [4]. HBs are commonly located in the posterior fossa and mostly occur as sporadic lesions that present by increased intracranial pressure (ICP) and cerebellar manifestations [5]. HB are often cystic lesions, but may be solid and characterize by being highly vascular [6]. Surgical resection is the main therapeutic option for HBs especially the symptomatic lesions [7].

Solitary fibrous tumor or Hemangiopericytoma (HPC) originates from the pericytes that surround the capillary walls [8]. HPC may be graded according to the prognosis and grade III HPC has malignant characteristics with aggressive growth and high probability of recurrence and extracranial metastasis [9]. HPC required total resection or resection with adjuvant radiation [8]. The blood supply of any tumor especially the highly vascular tumors must be delineated before surgical interference with special regard to its relation to the normal vasculature to avoid potentially dangerous situations and to optimize the maximal safe resection [10]. Pre-procedural embolization of highly vascular tumors is recommended to allow reduction of blood loss, need for blood transfusion and allow proper excision through demarcating the target lesion and thus improve surgical outcome [11].

1.1 Objectives

This study targets to outline the impacts of preoperative transarterial embolization (TAE) on the outcomes of surgical interventions for patients had highly vascular intracranial tumors.

1.2 Design

Prospective interventional study

1.3 Setting

Neurosurgery and Interventional Radiology Departments, Faculty of Medicine, Helwan University.

2. Patients & Methods

All patients presenting by clinical picture suggestive of the presence of brain space occupying lesion (SOL) were evaluated for exclusion and inclusion criteria.

2.1 Exclusion criteria

The presence of history of ischemic strokes or transient ischemic attacks, coagulopathy, vascuitis or other vascular disorders, allergy to the used dye, maintenance on fibrinolytic drugs, drugs increasing bleeding time, or adjuvant anticancer therapy for any other indications are the exclusion criteria. Also, patients requiring preoperative adjuvant therapy, or refused to participate in the study were exlcuded.

2.2 Inclusion criteria

The presence of operable, resectable intracranial highly vascular SOL in patients free of exclusion criteria are the inclusion criteria.

2.3 Clinical evaluation

Evaluation entails the collection of demographic data including age and gender and history taking concerning surgical interference for previous similar lesion for possibility of recurrence, history of malignant lesions elsewhere in the body for the possibility for the SOL to be a metastatic lesion. Then, full clinical examination was performed including collection of the presenting symptoms, and full ophthalmic examinations.

2.4 Radiologic evaluation

All enrolled patients underwent CT and MRI brain with contrast to localize the lesion and its maximal diameter, in either plane; coronal, axial, or sagittal plane. Lesions were categorized according to location, and previous treatments were noted. Then, Digital subtraction angiography (DSA) was performed to assess the lesion's vascularity and identify the main feeding vessel.

2.5 Embolization Procedure

Using high-resolution biplane DSA, with steroid coverage if indicated and by a 5F micropuncture set, after cannulating the right common femoral artery selective catheterization of cerebral arteries up to the feeding artery of the SOL was embolized through a microcatheter (Echelon 10; Covidien) that was advanced to the target vessel. Embolization was conducted using polyvinyl alcohol embolization particles, Gelfoam, or ethylene vinyl alcohol copolymer (Onyx). After completion of the embolization procedure, the sets were removed and compression was applied to the site of entrance.

2.6 Management plan

Patients showing manifestations increased ICP or had posterior fossa SOLs underwent preoperative insertion of ventriculo-peritoneal (VP) shunt especially if the fourth ventricle was obstructed. Patients had radiosensitive lesions were transferred to receive radiotherapy instead of surgery. Whenever, surgical intervention was indicated, the appropriate neurosurgical procedure according to the SOL location, preliminary vascularity and effect of embolization on vascularity, was undertaken and maximal possible resection was tried according to the possibility.

2.7 Collected data

2.7.1 Preoperative data

Age, gender, history of recurrence or other malignancies, presenting symptoms and findings on clinical and radiologic examinations. Also, type of the materials used for embolization and post-embolization complications were recorded.

2.7.2 Operative data

Time interval between embolization and surgery, intraoperative (IO) evaluation of outcomes of embolization as judged by the extent of devascularization, the identification of line of demarcation line between the embolized and normal blood supply brain tissues, the feasibility of complete resection, the need for blood transfusion and number of the used bags of freshly donated blood, operative time.

2.7.3 Postoperative (PO) data

PO ICU stay, surgical outcomes as regard manifestations, complications, total hospital stay and radiologic outcomes regarding the presence of remnants especially in case of partial resection.

Results of histopathological examination of the resected mass as regards tumor consistency and pathological diagnosis.

2.8 Statistical analysis

The obtained data concerning patients and materials, and outcomes are presented as average, standard deviation, numbers and ratios and were tabulated according to the requirements

3. Results

Through 1-year duration since Jan 2022 till March 2023, 28 patients fulfilled the inclusion criteria and enrolled in the study, while 7 patients were excluded during evaluation (Fig. 1). There were 7 males and 21 females with mean age of 42±12.6; range 23-66 years, but the majority were in age range of 30-50 years. Four patients had history of previous excision of intracranial SOL, two patients had history of other malignancies; a female had previous thyroidectomy and a male had lobectomy for Oat cell carcinoma of the right lung. Headache and blurred vision are the most frequent presenting symptoms that followed by hemiparesis and gait disturbances. Collectively, the rate of symptom per patient was 1.9, where 13 patients had one presenting symptom, 8 patients had two and 6 patients had three presenting symptoms, while two patients had >3 symptoms. On clinical examination ophthalmic findings are the most frequent and followed by motor power affection and four patients showed cerebellar gait. The frequency of signs per patient was 1.4, because 4 patients had three findings and 8 patients had two findings of which papilledema was a common finding (Table 1). According to the CT and MRI brain with contrast, as shown in table 2, the sphenoid wing, posterior cranial fossa and the olfactory groove and according to DSA, 13 SOL had single arterial supply with the commonest feeding vessels are

the middle meningeal artery and posterior inferior cerebellar artery, 11 SOL had double blood supply with the neuro-meningeal trunk is the main sharer and four SOL had triple supply and inferior lateral trunk of the falx is the main sharer of this triple supply (Table 2). All embolization procedures were conducted uneventfully without intra-procedural cancelling or complications. Embolization using PVA was provided for 13 (46.4%) patients, using Onyx in 10 procedures (35.7%) and Gel-Foam in only 5 procedures (17.9%). Embolization procedure allowed improvement of manifestations during the post-procedural period in all patients (100%) with varied extents. Unfortunately, catheterization procedure resulted in small femoral hematoma in two patients (7.1%) and skin sloughing in one case (3.6%), and embolization caused slight hemiparesis in one patient (3.6%) but improved spontaneously (Table 3).

During preoperative evaluations, among patients who were complaining of manifestations of increased ICP, 10 patients had posterior cranial fossa lesions and a patient had a lesion in the occipital lobe; these 11 patients required insertion of VP shunt for relief of high ICP. Another three patients (10.4%) received VP shunt after the end of surgery as a prophylactic measure to safeguard against increased ICP after surgery. The mean duration that elapsed between embolization and surgical excision was 38.6±18.9 hours; 15 and 10 patients underwent excision 24-h and 48-h after embolization, respectively, while two patients had surgery after 72-h and one patient after 96-h. All surgeries were conducted successfully within a mean operative time of 4.6±1.1 h; operation extended for >6h in only two patients, while was <4h in 8 patients and in the remaining 18 patients operative time was in rang of 4-6h (Table 3). Success of embolization procedure was evaluated intraoperatively as the extent of lesion devascularization that was good in 23 patients, fair in 3 patients and was poor in two patients. Also, as the evidence of the demarcation of cleavage line between lesion and normal brain tissue and was well-evident in 22 cases, fair in 4 cases and poor in two cases (Fig. 2). Further, dissection and debulking of the lesion was easy in 22 patients, fair in 3 patients and difficult in three cases. Twenty-two patients did not need blood transfusion, 5 patients required only one unit and only one patient received two units for a median number of transfused units of 0 [IQR: 0-0.5] units (Table 4). All patients were transferred to surgical ICU for immediate PO care and stayed for a mean duration of 28.7±6 hours and were discharged to neurosurgical wards. Fourteen patients stayed for 24-h in ICU, 8 patients for 30-h and 5 patients for 36-h, while only one patient stayed for 48-h. Hospital discharge was accomplished after a mean duration of ward stay of 2.4±0.6 days after ICU discharge; 18 patients stayed for two days in the ward, 9 patients stayed for three days and only one patient for four days. Two patients were transferred for radiotherapy center to receive the scheduled lines for hemangioblastoma (Table 5). Seventeen excised masses were soft in consistency, while 11 were firm. Pathological diagnosis of the excised masses was meningioma (n=17), HGB (n=6), HPC (n=3) and two metastatic adenocarcinoma (Table 6).

3.1 Case Presentations

3.1.1 Case 1

Female patient aged 66 years old with history of headache, blurring of vision and hemiparesis 4 months ago. On examination patient had papilledema grade I. CT and MRI brain with contrast showed highly vascular extra axial SOL. DSA showed double supply of the lesion ECA "NMT" and ICA "ILT ". Preoperative embolization was done using PVA particles (150-250 microns) without any complication. The surgery was done 24h later. Intraoperative, good devascularization allowed easy debulking and dissection of well demarcated soft tumor. Total resection was achieved and patient clinically improved. Histopathological examination revealed **Meningioma**.

3.1.2 Case 2

Female 29 years old complaining of severe headache, blurring of vision and unstable gait for 2 months. Patient had history of posterior fossa SOL excision 2 years ago. On examination, patient had papilledema grade II. CT and MRI brain with contrast showed posterior fossa SOL. DSA showed the feeders arising from PICA. V-P shunt was placed first. Preoperative embolization was done using Gel Foam without any postembolization complication. Surgical excision took place after 24 h from embolization. Intraoperative, poor devascularization made debulking and dissection difficult, the line of cleavage was poorly demarcated and the tumor was firm. The tumor was excised and the patient clinically improved. Histopathological examination revealed **Hemangioblastoma.**

3.1.3 Case 3

A 55-old female patient presenting by history of chronic headache and blurring of vision 1 years ago showed decreased visual acuity and papilledema grade II on ophthalmic examination and CT and MRI brain with contrast showed right sphenoid wing SOL. DSA showed multiple supply of the lesion from tentorial arcades, NMT and Meningo- hypophseal artery (Case 3a&c). Onyx TAE resulted in good devascularization (Case 3b&d) and surgery was performed 24-h after with easy debulking and dissection through a well demarcated line of cleavage of the soft tumor, which was completely excised and a single unit of RBCs was needed. Onyx TAE caused slight hemiparesis which totally improved 3 days later. Histopathological diagnosis was **meningioma**.

3.1.4 Case 4

Male patient aged 13 years old with history of epistaxis, voice changes and difficulty in breathing " mouth breathing ". CT and MRI nose and para nasal showed huge nasopharyngeal mass with some extension to middle cranial fossa. DSA showed double supply of the lesion from ECA "APA " and ICA " Petrous part ". Preoperative embolization was done using Onyx without any complication then, the tumor was surgically removed by transnasal endoscope after 24h from embolization. Intraoperative, good devascularization allowed easy debulking and dissection of the well demarcated soft tumor and no blood transfusion was needed. Marvelous improvement of the patient complaint " no epistaxis, no nasal tone and breathing difficulty improved. Histopathological examination revealed **nasopharyngeal angiofibroma.**

3.1.5 Case 5

29-year old female patient presented by history of blurring of vision, hearing loss, developed fits since 2 months

and conscious level was deteriorated. Ophthalmic examination detected papilledema grade III, Radiologic workup detected large cerebellopontine angle lesion with hydrocephalic and DSA show multiple supply of the lesion from cerebellar arteries, NMT and ILT. Preoperative VP shunt was inserted and Onyx TAE was done without PEC (Case 5a-d). Surgery was scheduled 2-d after TAE and during surgery TAE was found to result in good devascularization with good demarcated soft tumor and this allowed easy debulking and dissection of the tumor. Histopathological diagnosis: **cerebellopontine angle meningioma**.

3.1.6 Case 6

A 36-year old female patient complaining of headache, blurring of vision for 3 months. Examination showed papilledema grade II and right hemiparesis and Radiologic workup detected left intraventricular SOL and MCA was the arterial feeder. Onyx embolization was done without any PEC (Case 6a &b). Surgical excision of the tumor was done after 72-h and patient clinically improved. Intraoperative, TAE provided good devascularization, allowed easy debulking and dissection of the well demarcated soft tumor. Histopathological diagnosis: meningioma.

4. Discussion

Preoperative transarterial embolization (TAE) resulted in high rate of good devascularization of tumors and well-defined line of cleavage; 82.2% and 78.6%, respectively and this allowed easy dissection and debulking of 78.6% of lesions and shortened operative time to range between 3-5 h in 75% of cases. In line with these results, retrospectively, Catapano et al. [12] documented the excellent devascularization of skull base paragangliomas and facilitated resection in about 80% of patients after TAE. Also, Akimoto et al., [13] evaluated the surgical outcomes of 109 meningioma patients who underwent TAE, surgical resection and were followed for 1 year and reported improved complains in about 70% of patients, permanent complication rate of 1.8% and detected negative relation between meningioma recurrence and >80% resolution of tumor staining. Also, systematic review and meta-analysis performed by Schartz et al. [14] to evaluate the outcomes of meningioma surgical resection after TAE in 219 and surgical resection without TAE in 215 patients and found TAE was associated with significantly lower odds ratio of major surgery-related complications and odds ratio of TAE-related and total overall surgical complications with higher odds ratio of PO functional independence during follow-up in cases received TAE. The obtained results supported the previously reported by early prospective study that found preoperative TAE improved safety and efficacy of surgical excision of very vascular intracranial tumors [15-17]. Further, Brahimaj et al. [18] found simultaneous transarterial and transvenous embolization of jugular foramen, successfully allowed surgical resection with minimal blood loss and no blood transfusion was required or cranial nerve deficits were reported. Thereafter, Moscovici et al. [5] applied TAE for 17 HGBs of solid consistency with four of these SOLs showing tumor-related aneurysms and assured the success of TAE that was manifested as gross total resection in 91% and subtotal resection in 9% of cases with improved, stable and deteriorated functional status in 75%, 16% and 9% of patients, respectively. Furthermore, Hong et al. [10] tried TAE for occluding an aneurysm within a large right frontal dural-based lesion followed by open tumor resection in the same setting and reported completion of excision without complication, minimal blood loss, and improvement in presenting symptoms. One of the main advantages of TAE is the reduced intraoperative blood loss that spared blood transfusion in 23 patients and only one patient received two units and five patients received one unit of blood. These data are in hand with Iampreechakul et al. [19] who documented that TAE of angiomatous meningioma was safe and effective in reducing perioperative blood loss and facilitating total tumor resection. Also, Al-Mufti et al. [20] found TAE of meningiomas was safe and effectively reduced the perioperative blood loss as judged by the change in PO hemoglobin and hematocrit levels in relation to preoperative levels. Also, a recent retrospective study for TAE in cases of juvenile nasopharyngeal angiofibroma detected decreased blood loss during surgical removal by about 800 ml in embolized than non-embolized patients [21]. Post-embolization complications were encountered in one patient (3.4%) who developed transient hemiparesis that recovered before surgical interference and three patients developed minor catheter-site related complications for a total procedural complication rate of 13.4%. Similarly, Catapano et al. [12] reported facial palsy in one of seven patients (14.3%) received embolization of skull base paragangliomas. Also, Kothari et al., [22] detected TAE-related complication rate of 3.16% of a series of nasopharyngeal angiofibroma. Regarding the material used for TAE, onyx and PVA provided good devascularization with well line of demarcation that allowed easy excision in about 80% of cases and this outcome was superior to that achieved with Gel-Foam despite of the improvement encountered in all cases. These results go in hand with multiple recent studies that assured the efficacy of the non-adhesive liquid embolic agents as Onyx [23-26] and particle embolic agents as PVA [27-30]. Unfortunately, the only reported case of slight hemiparesis after embolization occurred secondary to onyx injection and this might be attributed to its fluidity that may allow its spread anywhere. In line with this assumption, earlier studies assured the efficacy of onyx to achieve complete occlusion, but blamed it for its liquid nature that allows its migration intracranially or into the parent artery [31] and these findings were approved recently using animal study tried onyx for superior rectal artery embolization and detected significant necrosis zone of the distal part of the rectum [32].

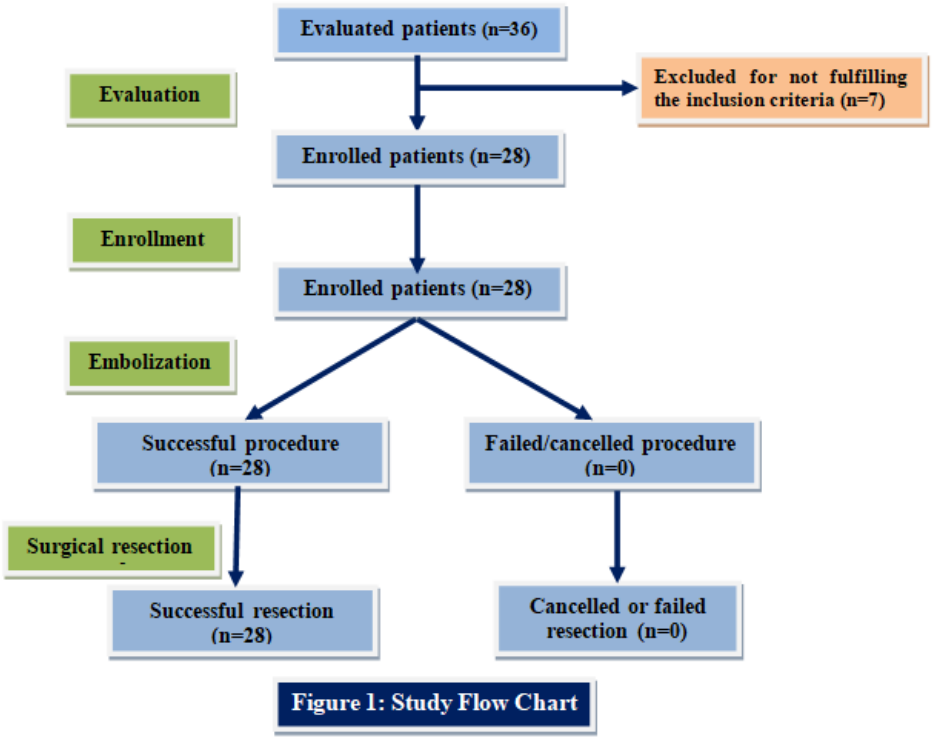

Figure 1: study flow chart

Table 1: Data of the enrolled patients

Data		Findings
Age (years)	20-30	6 (21.4%)
	31-40	8 (28.6%)
	41-50	8 (28.6%)
	51-60	3 (10.7%)
	>60	3 (10.7%)
	Mean (±SD)	42 (12.6)
Gender	Male	7 (25%)
	Female	21 (75%)
History of excision of intracranial SOL	Yes	4 (14.3%)
	No	24 (85.7%)
History of treatment for malignant lesions	Yes	2 (7.1%)
	No	26 (92.9%)
Frequency of the presenting symptom	One	13 (46.5%)
	Two	7 (25%)
	Three	6 (21.4%)
	>3	2 (7.1%)
	Symptom/patient	1.9
Frequency of the findings on clinical examination	No	3 (10.7%)
	One	14 (50%)
	Two	8 (25%)
	Three	4 (14.3%)
	Sign/patient	1.4

Table 2: The results of preoperative radiologic diagnostic modalities

Diagnostic modality	Findings		
CT and MRI brain with contrast for defining lesion site		Posterior cranial fossa	5 (17.9%)
		Occipital cranial lobe	1 (3.6%)
		Sphenoid wing	6 (21.4%)
		Brain convexity	3 (10.7%)
		Olfactory groove	4 (14.4%)
		Parasagittal	2 (7.1%)
		Midsagittal	2 (7.1%)
		Falcine	2 (7.1%)
		Cerebellopontine angle (CPA)	2 (7.1%)
		Intraventricular	1 (3.6%)
Digital subtraction angiography (DSA) for defining the feeding vessel	One feeding vessel	Middle meningeal artery (MMA)	4 (14.3%)
		Posterior inferior cerebellar artery (PICA)	3 (10.7%)
		Inferior lateral trunk (ILT) of falx	2 (7.1%)
		Middle cerebral artery (MCA)	2 (7.1%)
		Anterior inferior cerebellar artery (AICA)	1 (3.6%)
		Posterior cerebral artery (PCA)	1 (3.6%)
	Two feeding vessels	Neuro-meningeal trunk (NMT)+ ILT of falx	3 (10.7%)
		MMA +ILT of falx	3 (10.7%)
		NMT + meningeo-hypophyseal artery	2 (7.1%)
		MMA +MCA	1 (3.6%)
		Right neuromeningeal trunk + right AICA	1 (3.6%)
		APA+ petrous part of internal carotid artery	1 (3.6%)
	Three feeding vessels	Cerebellar artery +NMT+ILT	2 (7.1%)
		MMA+ occipital artery + artery of falx	2 (7.1%)

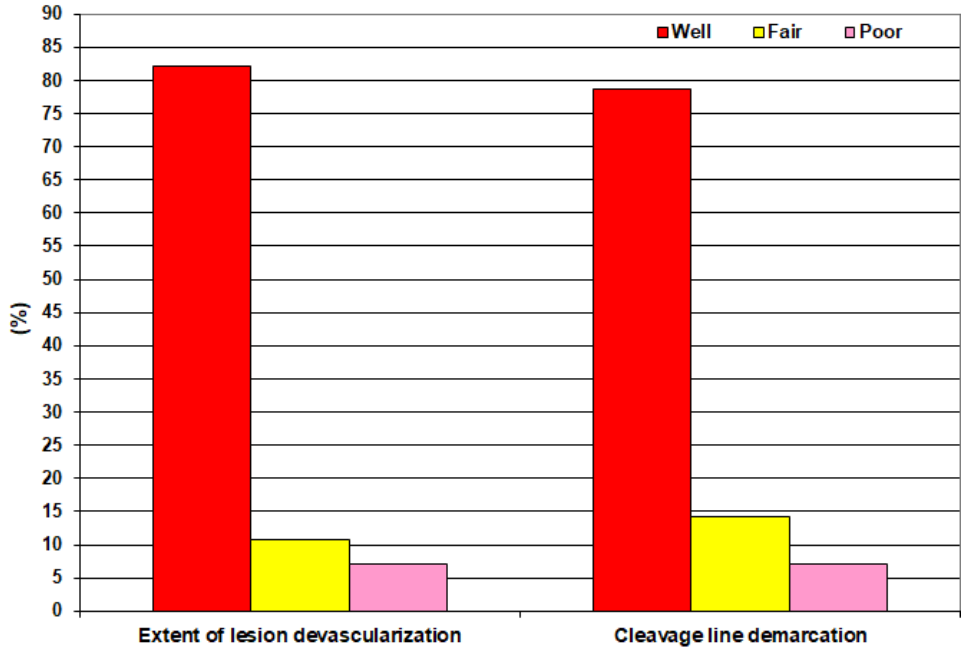

Fig. (2): Sucess rates of TAE procedure

Table 3: TAE data

Data			Findings
Material used for embolization	PVA		13 (46.4%)
	Gelfoam		5 (17.9%)
	Onyx		10 (35.7%)
Outcomes of EAT	Partial improvement of manifestations		28 (100%)
	Complications	Yes	4 (14.3%)
		No	24 (85.7%)
Post-embolization Complications (PEC)	Insertion site complications	Hematoma	2 (7.1%)
		Skin sloughing	1 (3.6%)
	Neurological	Hemiparesis	1 (3.6%)

Table 4: Operative data

Data			Findings
Perioperative VP-shunt	Preoperative		11 (39.3%)
	postoperative		3 (10.7%)
	Not required		14 (50%)
Time lag till surgery (h)	Frequency	24	15 (53.6%)
		48	10 (35.7%)
		72	2 (7.1%)
		96	1 (3.6%)
	Mean (±SD)		38.6 (±18.9)
Operative time (h)	Frequency	3-4	8 (28.6%)
		>4-5	13 (46.4%)
		>5-6	5 (17.9%)
		>6	2 (7.1%)
	Mean (±SD)		4.4 (0.95)
Extent of devascularization	Good		23 (82.2%)
	Fair		3 (10.7%)
	Poor		2 (7.1%)
Demarcation of line of cleavage	Well		22 (78.6%)
	Fair		4 (14.3%)
	Poor		2 (7.1%)
Dissection and debulking	Easy		22 (78.6%)
	Fair		3 (10.7%)
	Difficult		3 (10.7%)
Number of transfused blood units	No		22 (78.6%)
	One		5 (17.9%)
	Two		1 (3.5%)
	Median (IQR)		0 [0-0.75]

Table 5: Postoperative data

Data		Findings
ICU stay (h)	24	14 (50%)
	30	8 (28.6%)
	36	5 (17.9%)
	48	1 (3.5%)
	Mean (SD)	28.7 (6)
Hospital stay (days)	2	18 (64.3%)
	3	9 (32.2%)
	4	1 (3.5%)
	Mean (SD)	2.4 (0.6)
Need for PO adjuvant therapy	Yes	2 (7.1%)
	No	26 (92.9%)

Table 6: Pathological data

Data		Findings
Consistency of the excised mass	Soft	17 (60.7%)
	Firm	11 (39.3%)
Pathological diagnosis	Meningioma	17 (60.7%)
	HGB	6 (21.4%)
	HPC	3 (10.8%)
	Metastatic adenocarcinoma	2. (7.1%)

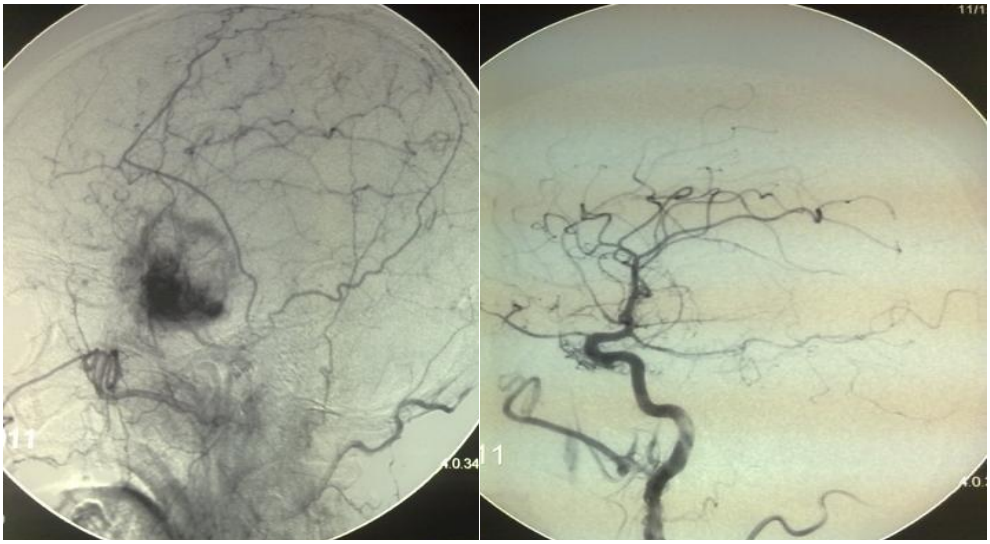

Fig 3: Case 1: Pre and post embolization DSA

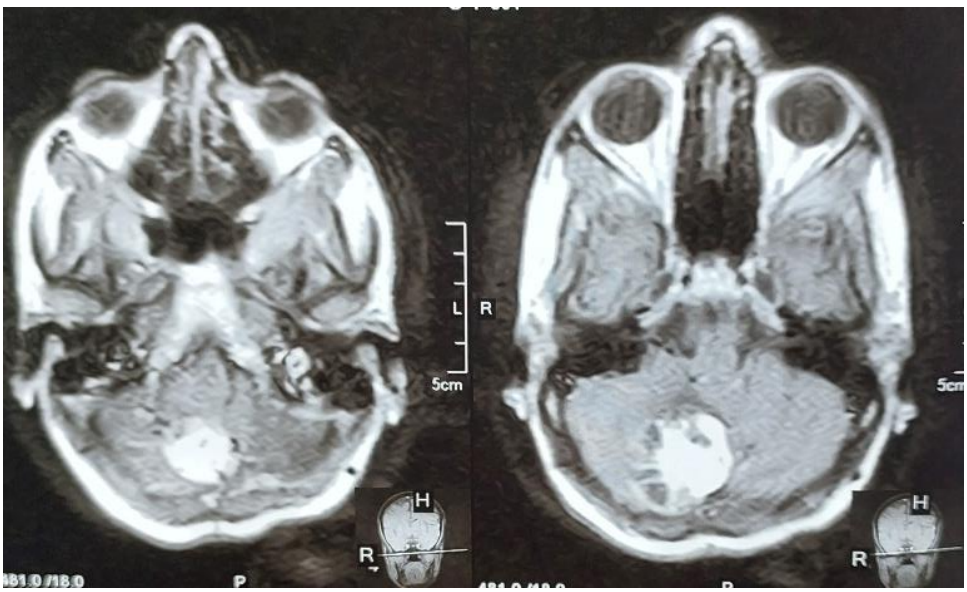

Fig 4: Case 2a: MRI brain with contrast showing posterior fossa SOL

Fig 5: Case 2b: Intraoperative image of the scar of the previous operation

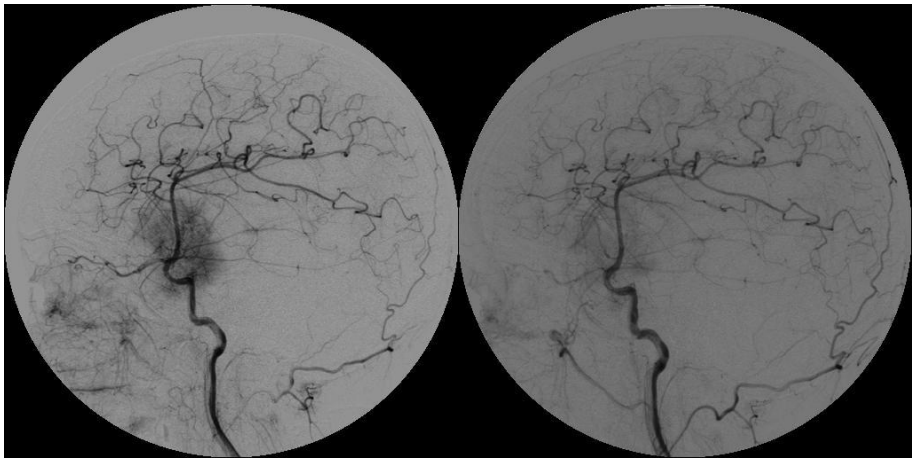

Fig 6: Case 3a: Pre-embolization DSA

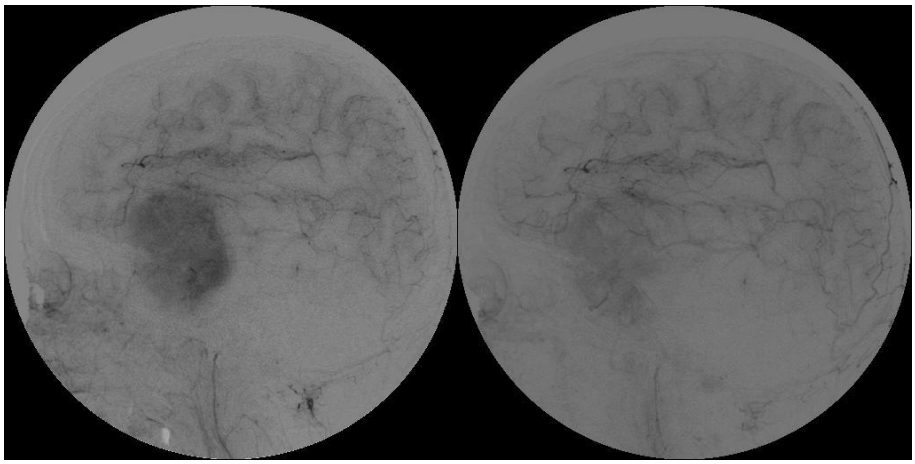

Fig 7: Case 3b: Post-embolization DSA

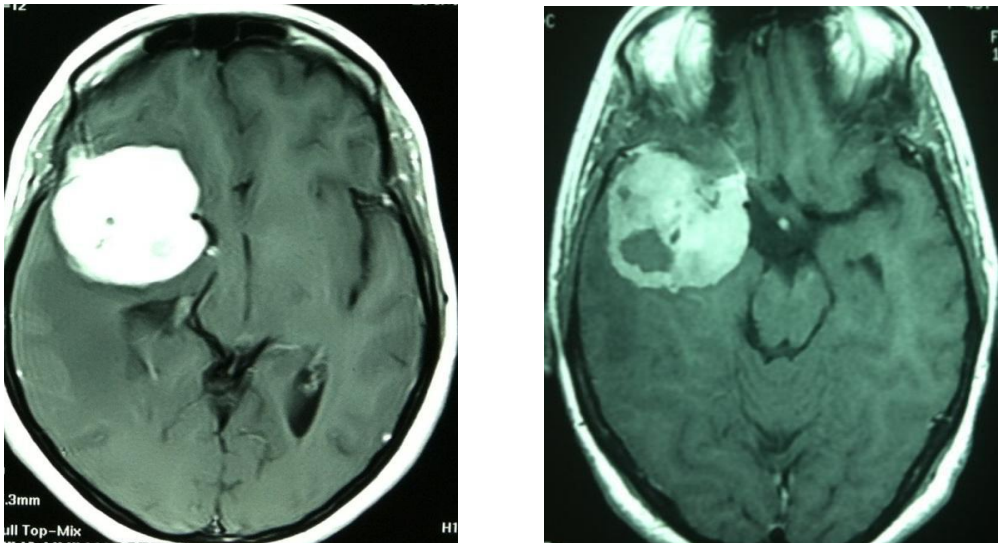

Fig 8: Case 3c: Pre-embolization MRI with contrast **Case 3d:** Post-embolization MRI with contrast

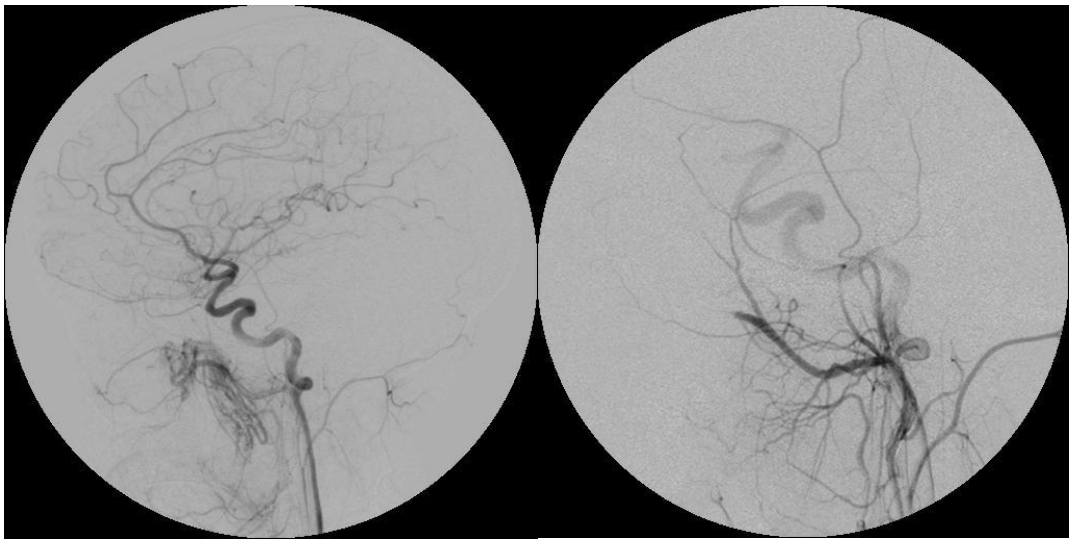

Fig 9: Case 4: Pre and post embolization DSA

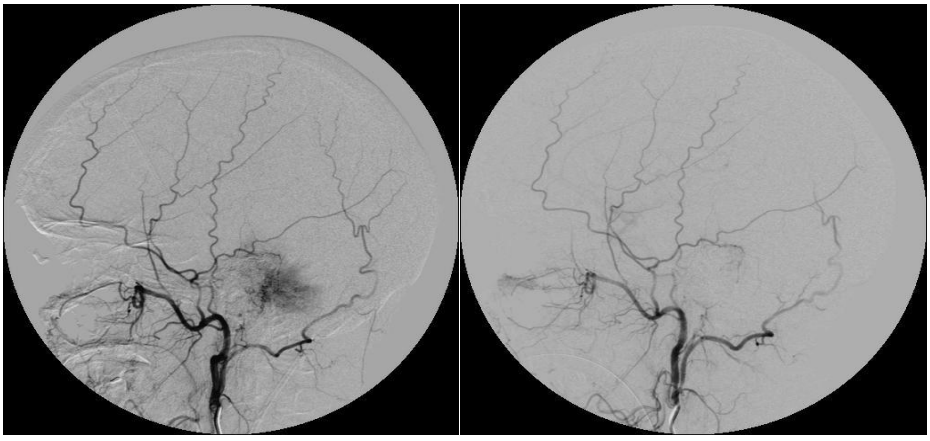

Fig 10: Case 5a &b: Pre and post embolization DSA showing diminution of blood vessels supplying the lesion

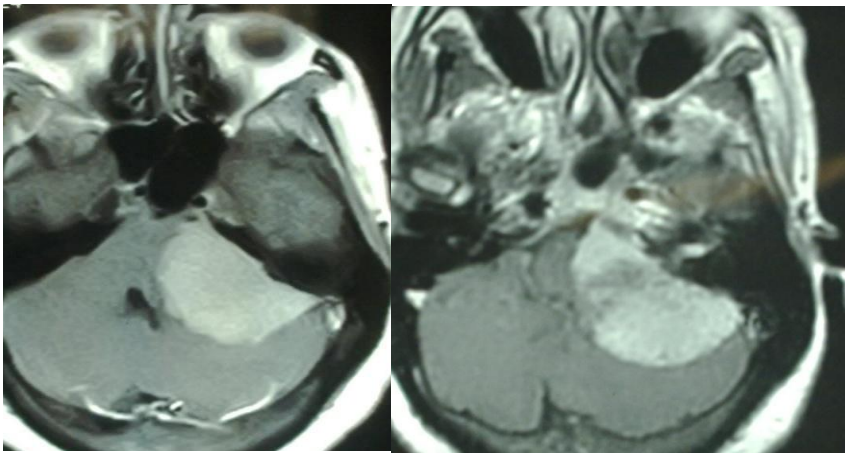

Fig 11: Case 5c &d: Pre and post-embolization MRI with contrast showing area of necrosis and shrinkage in tumor size

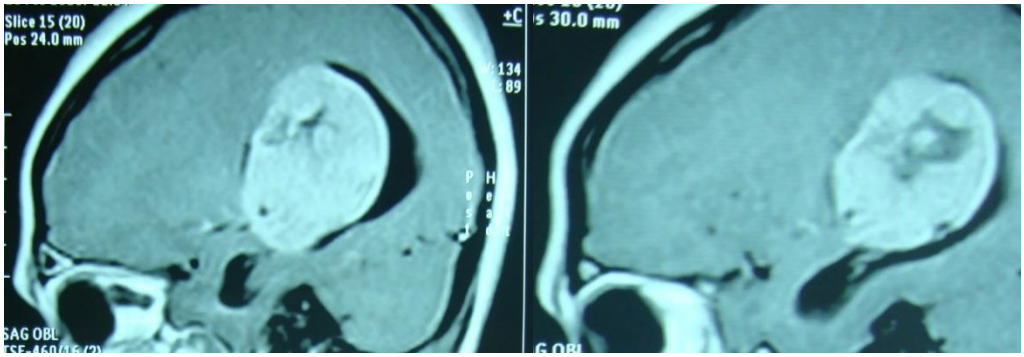

Fig 12: Case 6: Pre and post-embolization MRI brain with contrast showing area of necrosis and tumor size shrinkage after embolization

5. Conclusions

Transarterial embolization of highly vascular intracranial tumors is an effective preoperative strategy to facilitate surgical excision within acceptable operative time and good debulking of the tumor and spared the need for blood transfusion. TAE using onyx or PVA provide satisfactory tumor devascularization and well-define line of tumor demarcation.

6. Limitation

Long-term follow-up for embolization and surgical outcomes is mandatory to establish the safety and effectiveness of the applied procedures.

Recommendations

Comparative studies between types of materials used for TAE with using tumor type as an independent stable factor to establish the differences between various materials are required.

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