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## Endovascular Treatment of the Tentorial Dural Arteriovenous Fistulas. Case Series and Literature Review

### Abstract

**Introduction.** Dural arteriovenous fistulas (DAVFs) are vascular anomalies where arteries from the carotid or vertebral arteries directly drain into the dural venous sinuses. Symptoms can range from asymptomatic to severe, including hemorrhage, venous hypertension, and neurological deficits. Tentorial dural arteriovenous fistulas (TDAVFs), a rare subset occurring in the tentorium, represent up to 4% of all DAVFs. Traditionally, DAVFs have been treated surgically, but recent advancements in endovascular embolization have made it a first-line treatment, although the optimal approach is still debated.

**The aim.** To evaluate the efficacy and outcomes of endovascular treatment for TDAVFs.

**Materials and methods.** Between 2012 and 2024, 174 patients with DAVFs were treated at the Scientific-Practical Center of Endovascular Neuroradiology of the NAMS of Ukraine, including 8 patients with TDAVFs (mean age 58.5 years). All the patients with TDAVFs were symptomatic, with symptoms including hemorrhage (37.5%), headache, tinnitus, and seizures (62.5%). Endovascular treatment used liquid embolic agents and coils when required. Outcomes were assessed using postoperative angiograms and the modified Rankin Scale.

**Results.** Nine embolization sessions were performed; of these, 8 (88.9%) using n-butyl cyanoacrylate Histoacryl and 1 (11.1%) using Onyx. Complete shunt elimination was achieved in 75% of sessions; 25% had residual low-flow shunting, with vessels unsuitable for further catheterization. No neurological deterioration occurred. The mean length of hospital stay was 5.5 days. Follow-up angiography in 7 patients showed one case of symptom worsening and vessel recruitment, which was later fully treated with repeat transvenous embolization.

**Conclusions.** Endovascular embolization is an effective and safe treatment for TDAVFs. This case series indicates its efficacy but underscores the need for further randomized trials to compare all treatment modalities for tentorial and other deep-seated dural vascular lesions.

**Keywords:** *tentorium, embolization, liquid embolic agents, treatment outcome.*

**Introduction.** Dural arteriovenous fistulas (DAVFs) are vascular malformations where arteries originating from branches of the carotid or vertebral arteries drain directly into the dural leaflets of venous sinuses [1]. The clinical progression of DAVFs varies based on the

venous drainage pattern [2]. Symptoms can range from being asymptomatic to severe, with manifestations such as hemorrhage, venous hypertension, and neurological deficits. Tentorial dural arteriovenous fistulas (TDAVFs) are a rare type, representing 4-8% of all DAVFs [3]. These fistulas occur within the double-layered dural structure of the tentorium and its attachments, characterized by multiple arterial dural feeders converging into a single dural vein [4].

Compared to DAVFs located elsewhere, TDAVFs demonstrate the most aggressive neurological course, with intracranial hemorrhage rates between 60% and 75%, including potentially fatal bleeds in the posterior fossa [5,6].

Due to this significant risk, even in the absence of prominent clinical symptoms, aggressive treatment is required for TDAVFs. Treatment typically involves disconnecting the draining vein from the feeding dural arteries. Incomplete treatment can lead to the development of collateral vessels, maintaining the risk of hemorrhage [7].

Historically, treatment of DAVFs involved surgically ligating the draining vein, but the deep location of TDAVFs can complicate access. In recent years, endovascular embolization has become the preferred treatment, either as a standalone approach or combined with surgery [4,8,9]. However, the best approach for endovascular treatment remains debated, and data on the treatment of TDAVFs are very limited and most of them are case reports describing peculiarities of endovascular embolization over the last 5 years [10-20], underscoring the need for further studies.

**The aim.** To study the efficacy and results of the endovascular treatment of patients with TDAVFs.

**Materials and methods.** A total of 174 patients with DAVFs were treated at the Scientific-Practical Center of Endovascular Neuroradiology of the NAMS of Ukraine between 2012 and 2024, each undergoing at least one

endovascular embolization. Among these patients, 8 patients had TDAVFs. The mean age of this subgroup was 58.5 years, with an equal distribution of 4 men (50%) and 4 women (50%). All the patients presented with symptoms, and hemorrhagic manifestations were observed in 3 patients (37.5%), while the remaining 5 (62.5%) exhibited symptoms such as headache, tinnitus, and seizures. TDAVFs were categorized based on venous drainage patterns following the Cognard Classification (1995) [2]. Anatomical location of fistula point and feeder territories were analyzed (Table 1).

Each patient underwent a thorough clinical examination and routine laboratory tests. Data collected during hospitalization involved detailed analyses of patient history, symptoms, and clinical progression. Post-procedural care followed standard protocols. The primary goal of the embolization was to achieve complete obliteration of the arteriovenous shunts. The patients were fully informed about the procedure risks and provided informed consent.

Endovascular embolization utilized liquid embolic agents, including a mixture of n-butyl cyanoacrylate (nBCA) with Histoacryl® (B. Braun, Melsungen AG, Germany), iodized oil (Lipiodol®, Guerbet LLC, France), and ethylene vinyl alcohol copolymer (Onyx™, EV3, Irvine, USA). Detached coils were also employed in certain cases. The procedures were performed under general anesthesia with

**Table 1**

*Demographical and clinical peculiarities in patients with TDAVFs*

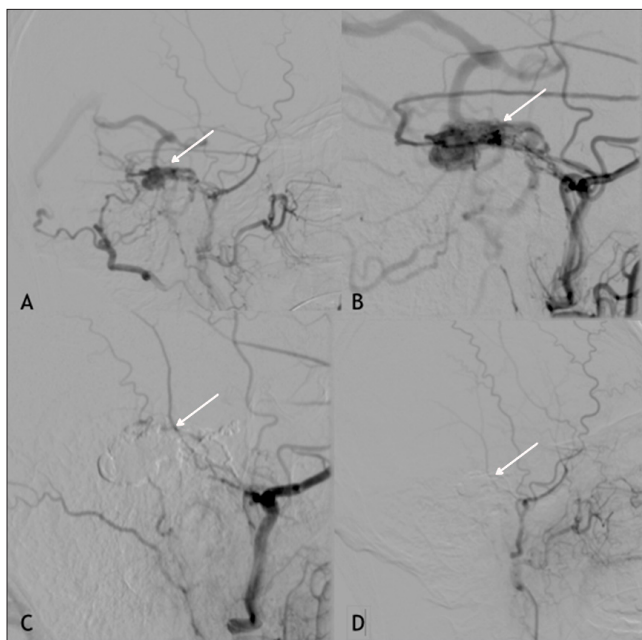
No.	Age	Sex	Presentation	Fistula point	Main feeding arteries	Classification (Cognard)	Primary treatment	Result	No of treatments	Follow-up
1	65	Male	Headache	Torcular	Occipital artery, MHT, posterior meningeal artery	III	Transarterial embolization	Total	1	Complete occlusion
2	59	Female	Vertigo, headache	Torcular	MMA, superficial temporal artery, occipital artery, MHT, posterior meningeal artery	IV	Transarterial embolization	Subtotal	1	N/A
3	58	Male	Headache & tinnitus	Galenic	Occipital artery	IV	Transarterial embolization	Total	1	Complete occlusion
4	62	Female	Hemorrhage	Torcular	MMA, occipital artery, MHT, posterior meningeal artery	I	Transarterial embolization	Total	1	Complete occlusion
5	54	Female	Hemorrhage	Galenic	MMA, occipital artery, MHT	IV	Transarterial embolization	Subtotal	2	Worthening
6	36	Male	Headache, tinnitus	Galenic	Superficial temporal artery, occipital artery,	IV	Transarterial embolization	Total	1	Complete occlusion
7	61	Female	Hemorrhage	Torcular	MMA, Occipital artery, MHT,	IV	Transarterial embolization	Total	1	Complete occlusion
8	54	Male	Headache, tinnitus, vertigo	Galenic	MMA, Occipital artery, Posterior meningeal artery	IV	Transarterial embolization	Total	1	Complete occlusion

N/A, not available; MMA, middle meningeal artery; MHT, meningohypophyseal trunk.

mild hypotension, using femoral access and heparinization (10,000 U). A 6F femoral sheath was placed, followed by catheterization of the internal carotid or vertebral artery, and embolization was performed via a microcatheter (Magic or Sonic, Balt, Montmorency, France). Surgical outcomes were evaluated using postoperative angiograms, and complications and techniques were assessed based on surgical reports. Treatment outcomes were measured using the modified Rankin Scale. Due to the small sample size, descriptive statistics were used, and data were presented as mean  $\pm$  SD.

**Results and discussion.** In 8 patients with TDAVF, 9 embolization sessions were performed. Of these, 8 sessions (88.9%) utilized nBCA, and 1 session (11.1%) used Onyx (Fig. 1). Detached coils were used during one procedure to reduce the flow in the arteriovenous shunts and prevent excessive distribution of the liquid embolic agent.

No procedural complications occurred, and 6 embolization sessions (75%) resulted in total elimination of arteriovenous shunting. In 2 patients (25%), residual low-flow shunting was present, but the feeding vessels were unsuitable for further catheterization. No patient experienced neurological decline after embolization, though all the subjects reported mild to moderate headaches, which were managed with analgesics. Postoperative recovery was uneventful, with symptom improvement noted at discharge. Two patients who presented with hemorrhage were transferred to rehabilitation. The mean length of hospital stay was 5.5 days.



**Fig. 1.** Angiograms (A and B) show TDAVF (arrows) with multiple feeding vessels from external carotid artery before embolization session. TDAVF was totally occluded with Onyx (arrows) without any complications (C and D)

Follow-up angiography was performed in 7 patients (87.5%). One patient who had subtotal embolization continued to experience symptoms, and recruitment of feeding vessels was observed 6 months post-procedure. This patient underwent a repeat transvenous embolization, achieving complete obliteration. Another patient declined further surgery, and follow-up was not available.

Tentorial DAVFs are more difficult to treat compared to DAVFs in other locations, often requiring multiple endovascular or surgical interventions. Surgical treatment is challenging due to the deep location, and endovascular treatment can be complicated by dural supply from both the internal and external carotid arteries [9].

The optimal treatment strategy remains controversial thus far; the current treatment strategies to this disease are listed below.

Surgical resection typically involves significant brain exposure and can be technically challenging due to the complex arterial supply around the tentorium. Zhou et al. reported that among 32 patients who underwent surgical obliteration, complete TDAVF closure was achieved in 87.5%, while the mortality rate was 6% [20]. Stereotactic radiosurgery is another potential treatment for DAVFs. According to Chen et al., tentorial fistulae treated solely with radiosurgery or combined with partial surgery/embolization resulted in a 58% complete obliteration rate [21]. However, the risk of hemorrhage remains unchanged until full obliteration, which can take 1-2 years after treatment [22].

Cannizzaro et al. systematic review highlighted a shift in treatment approaches, noting a decrease in surgical interventions for DAVFs, from 38.7% between 1980-1995 to 20.4% between 2006 and 2014. In contrast, the use of endovascular treatments rose from 16.1% to 48% during the same period [23].

Arterial embolization via the dural arteries, particularly from the internal carotid artery, poses a higher risk of intracranial embolic events. A complex anastomotic network between the intracranial and extracranial dural circulations, especially near the skull base, can result in the backflow of embolic agents, leading to distal embolic complications. In some instances, the occipital artery is the only viable extracranial access for endovascular procedures. However, its tortuosity – particularly in cases with high flow – can make it challenging to advance the microcatheter. During Onyx embolization, multiple dural arterial feeders may fill retrogradely before reaching the draining vein. Achieving venous penetration and occlusion is essential for ensuring the long-term closure of the fistula.

**Conclusions.** Endovascular embolization is a preferred treatment option for occluding tentorial DAVFs, demonstrating both effectiveness and safety in this challenging pathology. However, this small retrospective case series highlights the need for further randomized trials to compare all existing treatment modalities for

tentorial DAVFs and other deep-seated dural vascular lesions.

**Conflict of interest.** We declare no conflict of interest.

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## Ендоваскулярне лікування тензоріальних дуральних артеріовенозних нориць. Серія випадків та огляд літератури

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**Резюме.** Дуральні артеріовенозні фістули (ДАВФ) – це судинні аномалії, при яких артерії з сонних або хребетних артерій прямо впадають у дуральні венозні синуси. Симптоми ДАВФ можуть варіювати від безсимптомних до тяжких, включаючи кровотечу, венозну гіпертензію та неврологічні порушення. Тензоріальні ДАВФ є рідкісною підгрупою фістул, що формуються в ділянці намету мозочка, і становлять до 4 % всіх ДАВФ. Традиційно ДАВФ лікували хірургічним шляхом, але нещодавні досягнення в галузі ендоваскулярної емболізації зробили її лікуванням вибору, хоча оптимальний підхід все ще обговорюється.

**Мета** – оцінити ефективність та результати ендоваскулярного лікування тензоріальних ДАВФ.

**Матеріали та методи.** У період з 2012 по 2024 рік у ДУ «Науково-практичний центр ендоваскулярної нейрорентгенохірургії НАМН України» проліковано 174 пацієнти з ДАВФ, у тому числі 8 із тензоріальними ДАВФ (середній вік 58,5 року). Усі ДАВФ були симптомними, у тому числі кровотеча (37,5 %), головний біль, шум у вухах та судоми (62,5 %). Під час ендоваскулярного лікування використовували рідкі емболізуючі агенти та мікроспіралі за потреби. Результати оцінювали за допомогою післяопераційних ангиограм та модифікованої шкали Ренкіна.

**Результати.** Було проведено 9 сеансів емболізації, з них 8 (88,9 %) з nBCA-Histoacryl і 1 (11,1 %) з Онух. Повне усунення шунта було досягнуто в 75 % сеансів; у 25 % спостерігалось залишкове низькопотокове шунтування з непридатними для подальшої катетеризації судинами. Неврологічних погіршень після операцій не спостерігалось. Середня тривалість перебування у стаціонарі становила 5,5 дня. Наступна ангиографія була проведена у 7 пацієнтів, виявлено один випадок погіршення симптомів та появу нових судин, які пізніше були тотально емболізовані трансвенозним доступом.

**Висновки.** Ендоваскулярна емболізація є ефективним та безпечним методом лікування тензоріальних ДАВФ. Ця серія випадків показує її ефективність, але наголошує на необхідності подальших рандомізованих досліджень для порівняння всіх методів лікування тензоріальних та інших глибоко розташованих дуральних судинних уражень.

**Ключові слова:** намет мозочка, емболізація, рідкі емболічні засоби, результати лікування.

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