NEUROLOGY

Cite as: Archiv EuroMedica. 2024. 14; 2: e1. DOI 10.35630/2024/14/2.206

Received 21 March 2024;
Accepted 12 April 2024;
Published 15 April 2024

SELECTED PATHOLOGICAL CONDITIONS WITHIN THE CAVERNOUS SINUS

Bartosz Basiaga[1] ✉, ***Karolina Bednarz [2]***, ***Klaudia Żądecka-Kobiałka[3]***, ***Anna Putra[2]***, ***Magdalena Marchaj[4]***, ***Monika Nowicka-Jasińska[5]***, ***Paweł Frączyk[6]***, ***Sara Bieniek-Zając[7]***, ***Sebastian Baczkowski[8]***, ***Klaudia Krawiec[3]***, ***Krzysztof Bednarz[9]***

[1] *Bonifraterskie Medical Center Limited Liability Company Branch in Krakow, Poland*
[2] *SP ZOZ MSWiA in Katowice named after Sergeant Grzegorz Załoga, Katowice, Poland*
[3] *Lower Silesian Center of Oncology, Pulmonology, and Hematology, Wrocław, Poland*
[4] *Municipal Hospitals Group in Chorzów, Chorzów, Poland*
[5] *Academy Humanitas in Sosnowiec, Poland*
[6] *Medical University of Silesia, Faculty of Medical Sciences in Zabrze, Katowice, Poland*
[7] *Wrocław Medical University, Wrocław, Poland*
[8] *Independent Public Healthcare Facility in Bochnia, Blessed Marty Wiecka County Hospital, Bochnia, Poland*
[9] *University Clinical Center prof. K. Gibiński Medical University of Silesia in Katowice, Poland*

✉ ***bartoszbasiaga@gmail.com***

ABSTRACT

The neurosurgical literature shows that the effectiveness of the main sinus outflow in its main function depends on access to the anatomy and pathology in the presellar area and the development of neuroimaging methods. The pathology of the cavernous sinus is often revealed in imaging tests, which are often accompanied by other tests unrelated to the cause. Tumors located within the cavernous sinus pose a significant challenge for surgeons. Although it is often possible to decide to opt out, it is possible. Not only tumors can be located in the cavernous sinus and affect placement in any structure.

The aim of this work is to raise awareness of pathological conditions within the cavernous sinus.

Methods: Selected articles from Pubmed and specialist textbooks were analyzed in detail. We focused on selected pathological conditions occurring within the cavernous sinus, which a doctor may often encounter in his clinical work.

Conclusion: The cavernous sinus is a place where tumors and other pathologies arise. The development of imaging diagnostics allows neurosurgeons to more precisely determine the place within the sinus that has

changed, and access to it is quite a challenge. Numerous observations of clinical conditions are increasingly a source of knowledge that can provide a therapeutic trial, but also speed up the detection of potential changes.

Keywords: cavernous sinus, dura mater, optic nerve, trigeminal nerve, radiotherapy

INTRODUCTION

Much time has passed since the groundbreaking description of the cavernous sinus (CS), formerly referred to as a surgical "no man's land", and an increasing number of studies have contributed to the understanding of its microsurgical anatomy. [1] Awareness of the boundaries and walls included in the CS becomes a key and necessary necessity to determine the exact orientation, among others. tumor in relation to the surrounding neurovascular structures, but also vascular changes, infections, inflammations and injuries. Various anatomical constraints such as hard bones and cartilage, stiff ligaments and tendons, soft fatty tissue and loose fibrous tissues generate different pressures on the surface, among others. tumor and thus influence its direction, expansion, size, speed and morphology of growth. [2] This effect becomes particularly important in the skull base, where tumor growth is limited in space by the skull bones and dura mater.

The cavernous sinus is one of the most complex areas of the skull base. Includes: cranial nerves III, IV, V1, V2, VI; internal carotid artery, cavernous veins and adipose tissue and fibrous tissue. [1, 3]. Tumors such as meningiomas, neuromas, chordomas, and pituitary adenomas may extend from or drain into the cavernous sinus, causing microanatomy distortions, which poses an additional surgical challenge for neurosurgeons. [4]

The cavernous sinuses are two venous chambers closed by the dura mater and connected by a sinus. Therefore, intersection of pathologies between both sides is not uncommon.Each sinus receives and drains venous blood from the superior and inferior ophthalmic veins in turn, on both sides through the upper and lower petrosal sinuses. [5]

Cavernous sinus syndrome involving involvement of several cranial nerves may manifest clinically as Horner's syndrome, loss of sensation in the eyes and jaw. Cavernous sinus lesions that spread anteriorly from the orbital apex affect the optic nerve. [6]

Fernandez and other researchers in a study of 126 patients identified cancer (63%), vascular lesions (20%), inflammatory conditions such as Tolosa-Hunt syndrome (13%), and others (4%) as the most common causes of cavernous sinus disease.). Only two had an infectious etiology: Haemophilus influenzae causing thrombophlebitis and aspergillosis. The most common tumors were pituitary adenoma and meningioma, 36.25% and 31.25%, respectively. In this series, two HIV-infected patients were diagnosed with lymphoma. [7]

METHODS

We analyzed in detail articles from Pubmed and specialist textbooks. We focused on selected pathological conditions occurring within the cavernous sinus.

RESULTS AND DISCUSSION

HIV-RELATED CAVERNOUS SINUS DISEASE

In people infected with HIV, one would expect that the disease spectrum would be consistent with the patient's immunocompromised state, and that opportunistic infections and HIV-related cancers would be widespread. However, there is a lack of epidemiological data on cavernous sinus pathology in HIV patients. Difficult access to the sinus and the fact that these people are highly immunosuppressed discourage invasive diagnostic procedures. [8] The literature on the population of patients co-infected with HIV and struggling with cavernous sinus pathology consists mainly of case reports. Interestingly, cavernous sinus tuberculosis has not been previously reported in HIV-infected patients. In fact, cavernous sinus tuberculosis is a rare disease, even in immunocompetent patients. In one study related to cavernous sinus disease and HIV infection, 23 patients were recruited, the average age of which was 38 years, the majority of whom were women. Eight patients had newly diagnosed HIV infection, the rest were aware of HIV infection. [8]

Cavernous sinus disease in the course of HIV infection is a huge barrier, which is a big challenge for most specialists. The diagnosis itself is complicated, and the situation with treatment is similar. Biopsies for cavernous sinus disease performed by neurosurgeons are practically unavailable, even in tertiary (reference level) medical facilities. [8]

TUMORS AFFECTING THE CAVERNOUS SINUS

Using knowledge relating to tumor origin and tumor growth pattern, CS-related tumors can be divided into three categories:

- type I - tumor originating from CS,
- type II - tumor originating from the side wall,
- type III - foreign origin and involving CS. [9]

A pioneering breakthrough was made by Parkinson, West, and Dolenca, who described a surgical entry point for CS that has been adopted by most neurosurgeons operating in this region. The choice of approach to the lesion site depends directly on the exact location of the lesion, because e.g. intracavitary aneurysms and arteriovenous fistulas are generally smaller and do not cause significant deformations, allowing direct entry based on triangular corridors and anatomical layers of the dura mater. [9, 10] Those of larger size may show a high degree of anatomical distortion, which makes it difficult for the neurosurgeon to navigate within this area.

CS cavernous hemangiomas are benign and the only primary cavernous tumors, accounting for 13% of all intracranial cavernous hemangiomas. Total or partial resection of the hemangioma is the preferred treatment option (complex neurovascular systems make complete resection quite a challenge). [11]

Several surgical approaches have been detailed for hemangiomas located in the CS, and the type of craniotomy varies depending on the location of the tumor and the local invasion of the sella. Despite successful resections, mortality remains high, which is due to the possibility of bleeding during surgical intervention, but also to deficits in the central nervous system.

Stereotactic radiosurgery gives satisfactory results as primary and supportive therapy. [12] Tumor irradiation causes blood vessel thrombosis, thereby reducing the tumor volume, its size and even stopping its growth. [13] The application strategy in stereotactic radiosurgery covers small tumors below 3 cm, while for tumors larger than 3 cm, conventional radiotherapy is used (before surgery) to shrink the tumor and reduce the intensity of intraoperative bleeding. [12, 13]

In type II, i.e. a group of tumors originating from the lateral wall of the cavernous sinus, we most often encounter neuromas and meningiomas. Kehrki et al demonstrated that an arachnoid granuloma in the lateral wall is a possible source of meningioma in this region. [14] In this case, an attempt can be made to completely remove the tumor by working between the two layers of the dura mater. Partial resection is also often used because it is considered an effective means of controlling the tumor and alleviating the compressive symptoms of cranial neuropathy. [15]

Trigeminal schwannoma (TS) arising from the trigeminal ganglion in the outer layer of the lateral wall can be classified on the basis of origin as type II. The TS is most often clearly separated from the CS by an inner layer. The treatment uses surgical and radiosurgical methods to minimize postoperative symptoms. However, there is controversy regarding decompression followed by radiotherapy versus primary gamma knife radiosurgery. [16] In patients undergoing primary radiosurgery, additional surgical treatment after gamma knife surgery is warranted in many cases due to tumor enlargement or uncontrolled facial pain. [16]

Pituitary adenomas, which belong to type III, are biologically benign according to some researchers, and the parasellar infiltration itself is the result of a histological defect in the medial wall of the CS. [17] Modern neuroimaging has failed to delineate the medial wall of the CS (helping predict sinus invasion), while the distance between the two sides of the internal carotid artery (ICA) is a commonly used criterion in assessing the extent of adenoma invasion. Frank and Pasquini presented a five-stage endoscopic grading system for CS invasion, in which grade 2 and above is graded as CS invasion. [18] There are several surgical concepts in which residual and recurrent tumors are treated with radiosurgery and are characterized by endocrine remission.

Chordomas, polysarcomas and nasopharyngeal cancer are other representatives of type III. The former treated with surgical resection with access from the skull base, radiosurgery or endoscopic access through the nasal cavity - increase the tendency to complete remission. The situation is different in the case of nasopharyngeal cancer because it tends to invade the skull base (perineural spread along V2 or V3). The goal of treatment is to relieve pressure on the surrounding structures causing neurological symptoms. Stereotactic radiosurgery is considered as a palliative procedure aimed at reducing the severity of deficits in the central nervous system. [18]

CAVERNOUS SINUS THROMBOSIS

It is a rare and fulminant life-threatening condition. It occurs at an incidence of approximately 0.2-1.6 per 100,000 per year. [19] Among the etiological factors, it is worth mentioning facial infections, sinusitis, orbital cellulitis, pharyngitis or ear inflammation. A special group of people at increased risk of cavernous sinus thrombosis (CST) are those with diabetes, thrombophilia or conditions associated with impaired

immune response (chemotherapy, steroid therapy). [20, 21] Fever, headache, orbital edema, ophthalmoplegia, exophthalmos (fig. no. 3) - these are typical symptoms characterizing the patient's clinical condition. Quick diagnosis and implementation of effective treatment ensures a good prognosis. Thanks to the development of the pharmaceutical industry and the appearance of new antibiotics, mortality has decreased dramatically. [22]

To demonstrate thrombosis as a direct method, CT (computed tomography) and/or MRI (magnetic resonance imaging) are necessary. Non-contrast computed tomography most often reveals swelling, dilatation of the superior and inferior ophthalmic veins, and bulging of the lateral edges of the cavernous sinus. [23] CT/MRI with contrast shows the presence of heterogeneous and asymmetric filling defects, thrombosis of the superior ophthalmic vein, other venous tributaries, dural venous sinuses, and cerebral veins. This becomes important because it may determine the need to start using anticoagulants.

ORBITAL APEX DISORDERS IN CAVERNOUS SINUS SYNDROME

Orbital vertex disorders include:

1. orbital apex syndrome - Jacoda syndrome (OAS),
2. superior orbital fissure syndrome - Rochon-Duvigneaud syndrome (SOFS),
3. cavernous sinus syndrome (CSS).

CSS includes hypoesthesia of the cheek and lower eyelid and symptoms such as: proptosis, ptosis (paralysis of cranial nerves III, IV and VI), ophthalmoplegia, hypoesthesia of the forehead, upper eyelid and cornea on the same side due to involvement of the ophthalmic division of the trigeminal nerve. Additionally, CSS may present with oculosympathetic paresis (Horner's syndrome) due to involvement of the sympathetic portion adjacent to the cavernous segment of the ICA. [24]

Previously, the literature described these three syndromes separately based on anatomical location. However, it is currently believed that the disorders included in the syndromes have a similar cause, diagnostic assessment and management pattern. Moreover, these teams can be progressive: SOFS evolves into OAS or CSS. [24] The previously mentioned proptosis is caused by loss of extraocular muscle tone, retrobulbar edema or venous congestion. Optic nerve injury most often occurs in the intracanalicular portion of the optic nerve, especially in cases of traumatic injury. [25]

This is possible as a result of the close proximity of the dura mater of the optic nerve to the periosteum of the optic canal, which results in greater susceptibility of the nerve to pressure. Branches V1 and V2 of the trigeminal nerve pass through the lateral wall of the cavernous sinus and both may be involved in cavernous sinus syndrome. [26] The abducens nerve (VI) is more commonly involved in the CSS due to its location in the sinus compared to those in the lateral wall. [27]

The above disorders are classified on the basis of etiology, including: traumatic/iatrogenic, infectious, neoplastic.

ASPERGILLOSIS OF THE CAVERNOUS SINUS

It is a rare and potentially fatal infection that does not cause specific clinical symptoms, and its deep anatomical location makes early diagnosis difficult. Aspergillus infections are divided into invasive and non-invasive. Invasiveness involves penetration into blood vessels and the central nervous system. This type occurs very often in patients with: reduced immunity, type 2 diabetes, long-term steroid users, hematological cancers, but also, as mentioned at the beginning, in people infected with HIV. [28, 29] The hematogenic spread of Aspergillus can lead to invasion of any organ. The digestive tract, urogenital system, blood vessels, and central nervous system are typical places where the infection spreads. [30] Intracranial aspergillosis may lead to chronic meningitis and may also cause brain abscesses. By penetrating blood vessels, the mycelium increases the likelihood of inflammation, leading to thrombosis, microaneurysms, aneurysms, and even cerebral ischemia. [30]

INTRAVASCULAR FISTULA OF THE CAVERNOUS SINUS

Cavernous sinus dural arteriovenous fistula (CS-DAVF) is an abnormal arteriovenous communication involving the dura mater within or near the wall of the CS. In CS-DAVF, retrograde arterialized flow in the draining veins causes characteristic symptoms. [31] Asymptomatic high-flow CS-DAVFs can close spontaneously, but symptomatic high-flow CS-DAVFs can rarely close spontaneously. [32] Therefore, treatment of symptomatic fistulas is recommended. Currently, endovascular treatment (EVT) is the most common method; radiosurgery is used less frequently, most often as an adjunct to unsatisfactory endovascular treatment. Classification systems (of which there are several) provide useful information on the anatomy and hemodynamics of the fistula, which may further assist in planning access to the fistula during EVT. [33] The CS contains several compartments, but most often the fistula part does not cover the

entire sinus. Often the fistula part is called the fistula sac, which is cylindrical and separated from the main lumen. It is located in the posterior compartment of the cavernous sinus and connects with the intercavernous sinus.

The distinguished angiographic changes include:

1. early opacified surface in the early phase of catheter angiography,
2. a jellyfish-like sign indicating the convergence of branches of the arterial supply at the point of the fistula,
3. changes in the density of the contrast medium from dark in the artery to gray in the veins at the point of the fistula,
4. tortuous and enlarged arteries may indicate a fistula point. [34, 35]

Access types:

1. through the femoral vein,
2. transorbital approach,
3. through other punctures or incisions in the head and neck vein (access to the transcranial vein - middle cerebral vein; access through the foramen ovale - basilar skull vein).

Currently, minimally invasive stereotactic gamma-knife radiosurgery (SGKR) has become an alternative primary treatment for DAVF. Using a therapeutic radiation dose of 20-50 Gy, SGKR can induce target vessel damage, thereby obliterating the DAVF. [36]

CONTENT OF THE REVIEW

The cavernous sinus is a place where tumors can be located. Their growth and expansion into adjacent structures often cause neurological symptoms. However, pathologies within the cavernous sinus are still detected in the so-called opportunity - diagnosis of other diseases. CS lies in the line of skull base fractures and in these cases, damage to the internal carotid artery and bleeding directly into the sinus venosus occur relatively often. A characteristic symptom of this aneurysm is severe extrusion of the eyeball. Inflammation from the paranasal sinuses to extrusion of skin lesions located in a specific place on the face - known as the triangle of death - may lead to inflammation of the cavernous sinus. Thrombosis, although rare, is particularly dangerous because it may result in a stroke. The development of imaging diagnostics allows neurosurgeons to more precisely specify the place within the sinus that has been changed, and access to it is quite a challenge. Radiotherapy and irradiation often become a palliative form of help in patients with a lesion located in the cavernous sinus.

CONCLUSIONS

Pathologies within the cavernous sinus pose a challenge to the clinician. A more common clinical manifestation is cranial nerve dysfunction, and the main symptom is often visual disturbances. The extent of surgical resection and the histological grade of tumor lesions are particularly important and are related to the long-term prognosis. A key development is the use of radiotherapy in cancerous tumors, which often complements treatment. Early removal, appropriate treatment and surgical approach may allow maintaining neurological functions, thus improving the quality of life of patients. Therefore, it is crucial to know the anatomy of the sinus, possible surgical approaches and the potential damage associated with them.

REFERENCES

1. Parkinson D. Lateral sellar compartment O.T. (cavernous sinus): History, anatomy, terminology. *Anat Rec.* 1998;251:486–90. DOI: 10.1002/(SICI)1097-0185(199808)251:4<486::AID-AR7>3.0.CO;2-Q
2. Sansone BC, Delsanto PP, Magnano M, Scalerandi M (2001) Effects of anatomical constraints on tumor growth. *Physical Review E* 64
3. Francois P, Travers N, Lescanne E, Arbeille B, Jan M, et al. (2010) The interperiosteo-dural concept applied to the perisellar compartment: a microanatomical and electron microscopic study. *Journal of neurosurgery* 113: 1045–1052. DOI: 10.3171/2010.1.JNS081701
4. Tang Y, Booth T, Steward M, Solbach T, Wilhelm T (2010) The imaging of conditions affecting the cavernous sinus. *Clinical radiology* 65: 937–945. DOI: 10.1016/j.crad.2010.06.009
5. Standring S. *Gray's anatomy: The anatomical basis of clinical practice*. 41st ed. Book. 2015;1562.
6. Lee JH, Lee HK, Park JK, Choi CG, Suh DC. Cavernous sinus syndrome: Clinical features and differential diagnosis with MR imaging. *Am J Roentgenol*. 2003;181(2):583–590. DOI:

10.2214/ajr.181.2.1810583

7. Fernández S, Godino O, Martínez-Yélamos S, et al. . Cavernous sinus syndrome: A series of 126 patients. *Medicine (Baltimore)*. 2007;86(5):278–281. 10.1097/MD.0b013e318156c67f DOI: 10.1097/MD.0b013e318156c67f
8. Wells CD, Moodley AA. HIV-associated cavernous sinus disease. *South Afr J HIV Med*. 2019;20(1):862. Published 2019 Mar 20. DOI: 10.4102/sajhivmed.v20i1.862
9. Chotai S, Liu Y, Qi S. Review of Surgical Anatomy of the Tumors Involving Cavernous Sinus. *Asian J Neurosurg*. 2018;13(1):1-8. DOI: 10.4103/ajns.AJNS_26_16
10. Yasuda A, Campero A, Martins C, Rhoton AL, Jr, de Oliveira E, Ribas GC. Microsurgical anatomy and approaches to the cavernous sinus. Neurosurgery. 2008;62(6 Suppl 3):1240–63. DOI: 10.1227/01.neu.0000333790.90972.59
11. Goel A. The extradural approach to lesions involving the cavernous sinus. *Br J Neurosurg.* 1997;11:134–8. DOI: 10.1080/02688699746483
12. Thompson TP, Lunsford LD, Flickinger JC. Radiosurgery for hemangiomas of the cavernous sinus and orbit: Technical case report. *Neurosurgery.* 2000;47:778–83. DOI: 10.1097/00006123-200009000-00052
13. Wang X, Mei G, Liu X, Dai J, Pan L, Wang E. The role of stereotactic radiosurgery in cavernous sinus hemangiomas: A systematic review and meta-analysis. *J Neurooncol.* 2012;107:239–45. DOI: 10.1007/s11060-011-0753-8
14. Kehrli P, Maillot C, Wolff Quenot MJ. Les gaines des nerfs crâniens dans la paroi latérale de la loge parasellaire. Etude embryologique et anatomique [Sheaths of cranial nerves in the lateral wall of the cavernous sinus. An embryological and anatomical study]. Neurochirurgie. 1995;41(6):403-12. French. PMID: 8815415.
15. O'Sullivan MG, van Loveren HR, Tew JM Jr. The surgical resectability of meningiomas of the cavernous sinus. Neurosurgery. 1997 Feb;40(2):238-44; discussion 245-7. PMID: 9007855.
16. Fukaya R, Yoshida K, Ohira T, Kawase T. Trigeminal schwannomas: Experience with 57 cases and a review of the literature. *Neurosurg Rev.* 2010;34:159–71. DOI: 10.1007/s10143-010-0289-y
17. Ceylan S, Anik I, Koc K. A new endoscopic surgical classification and invasion criteria for pituitary adenomas involving the cavernous sinus. *Turk Neurosurg.* 2011;21:330–9. DOI: 10.5137/1019-5149.JTN.4149-11.0
18. Frank G, Pasquini E. Endoscopic Endonasal Cavernous Sinus Surgery, with Special Reference to Pituitary Adenomas. *Pituitary Surgery - A Modern Approach Front Horm Res.* 2006;34:64–82. DOI: 10.1159/000091573
19. Plewa MC, Tadi P, Gupta M. Cavernous Sinus Thrombosis. 2023 Jul 3. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan–. PMID: 28846357.
20. Matthew T.J.H., Hussein A. Atypical cavernous sinus thrombosis: a diagnosis challenge and dilemma. *Cureus.* 2018;10(12)DOI: 10.7759/cureus.3685
21. Eltayeb A.S., Karrar M.A., Elbeshir E.I. Orbital subperiosteal abscess associated with mandibular wisdom tooth infection: a case report. *J. Maxillofac. Oral Surg.* 2019;18(1):30–33. DOI: 10.1007/s12663-017-1074-z
22. Bhatia H, Kaur R, Bedi R. MR imaging of cavernous sinus thrombosis. *Eur J Radiol Open*. 2020;7:100226. Published 2020 Mar 3. DOI: 10.1016/j.ejro.2020.100226
23. Deliran SS, Sondag L, Leijten QH, Tuladhar AM, Meijer FJA. Hoofdpijn: denk aan sinus-cavernosustromboflebitis [Headache: consider cavernous sinus thrombophlebitis]. Ned Tijdschr Geneeskd. 2018 Aug 16;162:D2907. Dutch. PMID: 30212024.
24. Yeh S, Foroozan R. Orbital apex syndrome. *Curr Opin Ophthalmol* 2004; 15: 490–498. PMID: 15523194 DOI: 10.1097/01.icu.0000144387.12739.9c
25. Steinsapir KD, Goldberg RA. *Traumatic optic neuropathy: An evolving understanding* . 2011; 151: 928–933. PMID: 21529765 DOI: 10.1016/j.ajo.2011.02.007
26. Bone I, Hadley DM. Syndromes of the orbital fissure, cavernous sinus, cerebello- pontine angle, and skull base. J Neurol Neurosurg Psychiatry. 2005 Sep;76 Suppl 3(Suppl 3):iii29-iii38. doi: 10.1136/jnnp.2005.075259. PMID: 16107388; PMCID: PMC1765699. DOI: DOI: 10.1136/jnnp.2005.075259
27. Gronski HW, Creely JJ., Jr Carotid-cavernous fistula: A complication of maxillofacial trauma. *South Med J* 1975; 68: 1096–1102. DOI: 10.1097/00007611-197509000-00011
28. Brenet E, Boulagnon-Rombi C, N'guyen Y, et al. Cavernous sinus thrombosis secondary to aspergillus granuloma: a case report and review of the literature. *Auris Nasus Larynx* 2016;43:566–9. DOI: 10.1016/j.anl.2016.01.007

29. Cheung EJ, Scurry WC, Isaacson JE, McGinn JD. Cavernous sinus thrombosis secondary to allergic fungal sinusitis. Rhinology. 2009 Mar;47(1):105-8. PMID: 19382506.
30. Picher MR, Parisi JE, Klaas JP. A woman in her 60s with chronic meningitis. *JAMA Neurol* 2017;74:348–52. DOI: 10.1001/jamaneurol.2016.2388
31. Zyck S, De Jesus O, Gould GC. Dural Arteriovenous Fistula. 2023 Aug 23. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan–. PMID: 30335307.
32. Fang B, Qian C, Yu J, Xu L, Jiang D, Xu J. et al. Transarterial Embolization of Cavernous Sinus Dural Arteriovenous Fistulas with Ipsilateral Inferior Petrosal Sinus Occlusion via the Ascending Pharyngeal Artery. World Neurosurg. 2018;117:e603–e11. DOI: 10.1016/j.wneu.2018.06.098
33. Leone G, Renieri L, Enriquez-Marulanda A, Dmytriw AA, Nappini S, Laiso A. et al. Carotid Cavernous Fistulas and Dural Arteriovenous Fistulas of the Cavernous Sinus: Validation of a New Classification According to Venous Drainage. World Neurosurg. 2019;128:e621–e31. DOI: 10.1016/j.wneu.2019.04.220
34. Guo H, Yin Q, Liu P, Guan N, Huo X, Li Y. Focus on the target: Angiographic features of the fistulous point and prognosis of transvenous embolization of cavernous sinus dural arteriovenous fistula. Interv Neuroradiol. 2018;24:197–205. DOI: 10.1177/1591019917751894
35. Sato M, Izumi T, Matsubara N, Nishihori M, Miyachi S, Wakabayashi T. Evaluation for shunted pouches of cavernous sinus dural arteriovenous fistula and the treatment outcome of transvenous embolization. Interv Neuroradiol. 2018;24:189–96. DOI: 10.1177/1591019917743064
36. Park SH, Park KS, Kang DH, Hwang JH, Hwang SK. Stereotactic Radiosurgery for Dural Carotid Cavernous Sinus Fistulas. World Neurosurg. 2017;106:836–43. DOI: 10.1016/j.wneu.2017.04.143

back