Review article

Isolated tectal cavernomas: A comprehensive literature review with a case presentation

Mohammed M. Al Barbarawi a,1, Hasan A. Asfour b,1, Suhair M. Qudsieh c, Safwan O. Alomari d, Ala M. Barbarawi a, Sara H. Ouda e, Mohammed Z. Allouh e,f,*

a Division of Neurosurgery, Department of Neuroscience, Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan
b University Hospitals of Leicester NHS Trust, Leicester Royal Infirmary, Leicester LE1 5WW, UK
c Department of Clinical Medical Sciences, Faculty of Medicine, Yarmouk University, Irbid, Jordan
d Department of Neurosurgery, Johns Hopkins University School of Medicine, Baltimore, Maryland, USA
e College of Medicine and Health Sciences, United Arab Emirates University, Al Ain, United Arab Emirates
f Faculty of Medicine, Jordan University of Science and Technology, Irbid, Jordan

HIGHLIGHTS

- We reviewed and statistically analyzed all reported cases of isolated tectal cavernoma in PubMed literature.
- Isolated tectal cavernoma is not associated with specific sex or a certain age.
- The most common complication associated with this condition is hemorrhage (64%).
- Parinaud’s Syndrome has been associated with some cases, with its presence being male predominant.
- Lesion size is significantly associated with outcome as larger lesions (>11 mm) are more likely to induce persistent deficit.
- Surgical resection is the ultimate management modality as most surgically treated cases ended with complete recovery (79%).

ARTICLE INFO

Keywords:
Angioma
Vascular malformation
Tectum
Parinaud’s Syndrome
Intraventricular hemorrhage

ABSTRACT

Intracranial cavernous angiomas or cavernomas (ICCs) are abnormal blood-filled vasculatures made of mono-endothelial layer and characterized by their bubble-like caverns. Brainstem cavernomas (BSCs) is a critical form of ICCs since slight changes in the lesion can result in devastating or life-threatening outcomes. We hereby present a rare case of BSC developed in the mesencephalic tectum with intraventricular bleeding and Parinaud’s Syndrome. Our patient was managed by complete surgical resection of the lesion through an infra-tentorial supracerebellar approach. Additionally, we reviewed and analyzed the hitherto reported cases of isolated tectal cavernomas (TCs) in the literature, including our case, to elucidate the main factors associated with the management outcomes of TCs. There have been 25 cases of isolated TC reported until now. Most of the patients were adults between 18–77 y of age, except for two children (7 and 13 y). There was no sex predominance. Symptomatic patients presented with headache 56%, altered level of consciousness 24%, and/or double vision 20%. Most cases (64%) had hemorrhagic lesions at presentation, and 60% of all cases experienced recurrent hemorrhages. Parinaud’s Syndrome was recorded in five cases, including the current one. All cases affected with Parinaud’s were males. Lesion size was a determinant of the outcome as larger lesions were more likely to result in persistent deficits. Surgical resection of the lesion was an effective management modality with ~79% (15/19) of patients who underwent surgery ended up with complete recovery.

* Corresponding author.
E-mail address: m.allouh@uaeu.ac.ae (M.Z. Allouh).

https://doi.org/10.1016/j.heliyon.2022.e09244
Received 26 October 2021; Received in revised form 1 December 2021; Accepted 30 March 2022
2405-8440/© 2022 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
1. Introduction

Cavernous angiomas or cavernomas are considered one of five major categories of benign vascular malformations in the central nervous system (CNS), which also include: i) telangiectasia (capillary angiomas), ii) varices, iii) venous angiomas, and iv) arteriovenous malformations [1]. Morphologically, cavernomas are raspberry-like clusters of low-flow sinusoidal channels, known as caverns, without intervening brain tissue. These caverns are lined by a single endothelial layer and, unlike normal blood vascular channels, lack smooth muscle and connective tissue layers [2]. This vulnerable architecture renders cavernomas to bleed easily and recurrently, resulting in a range of neurological symptoms like headaches, seizures, and neurological deficits, or even death. However, following the advent of magnetic resonance imaging (MRI), there has been a remarkable increase in the number of asymptomatic occult cavernomas detected incidentally, which could progress into symptomatic lesions in the future [3].

Intracranial cavernomas (ICCs) are found in up to 0.5% of the general population and tend to occur more often within the supra-tentorial cavity [4]. However, brainstem cavernomas (BSCs), which account for 4–35% of all ICCs, is a critical type of cavernomas, based on their location, since minimal changes of these lesions can result in life-threatening outcomes [5, 6]. Tectal cavernomas (TCs) comprise an extremely rare type of BSCs that develops within the tectal plate of the midbrain [7]. They constitute a special entity of BSCs due to their particular location on the dorsal aspect of the mesencephalon that interferes with both auditory and visual pathways and complicates any handling surgical approach [7]. The TCs can occur either concomitantly with other cavernomas elsewhere in the CNS or as solitary lesions [8]. To the best of our knowledge, there have been only twenty-five reported cases of solitary TC in the literature, including our case.

In this communication, we report a unique case of solitary TC with recurrent intraventricular hemorrhages and a reversible Parinaud’s Syndrome after successful surgical resection of the lesion. Additionally, we review all cases of solitary TC available in the literature and statistically analyze their main epidemiologic and clinical features to reveal the main factors associated with TC management outcomes.
2. Case presentation

An 18-year-old male with no previous history of epilepsy or other health issues presented to our emergency department with severe headache and inability to produce comprehensible sounds. There was no associated fever, neck stiffness or photophobia; there was no history of recent infection or head trauma; the patient was not on any medication. Before he arrived at our hospital, his mother found him lying in his bed in a generalized tonic posture with no response; there were no clonic movements, up rolling of eyes, or tongue biting. By reaching our hospital, he had vomited three times each of a teacup volume. On examination, his vital signs were within normal range. He had a decreased level of consciousness with Glasgow Coma Scale (GCS) was 9/15. His GCS was recorded as follows: producing incomprehensible sounds, localizing the painful stimulus, and opening eyes in response to pain. The patient had small-sized pupils with sluggish reaction to light. He had mild squat and downward gazing while other cranial nerves were grossly intact. He was able to move all limbs in all directions (muscle power of 5/5); he had normal muscle tone and reflexes. A decision for intubation and ventilation was taken and urgent computed tomography (CT) scan of the brain was done which showed a lesion suggestive of a diffuse hemorrhagic or vascular lesion in the tectal plate of the midbrain with concurrent intraventricular hemorrhage (IVH) in the third and the fourth ventricles.

The patient underwent an urgent right frontal External Ventricular Drainage (EVD) after which he was admitted to the ICU. On day three, the patient was extubated since his vital signs were within normal range, GCS was back to 15/15, and he had no motor deficits. The pupils were mid-sized and reactive but there was overt bilateral abducent nerve palsy with convergent squint and limited upward eye gazing associated with eyelid retraction (Collier’s sign) suggestive of Parinaud’s Syndrome.

The patient continues to improve gradually, and –on day nine– the CSF from the EVD was clear, and a brain CT showed no remaining IVH. Therefore, the decision was made to remove the EVD. However, his level of consciousness deteriorated (GCS = 12/15) few hours after the EVD removal. Brain CT scan revealed IVH (grade 2), which was then managed by another right frontal EVD. Magnetic resonance imaging (MRI) without (Figure 1A) and with contrast (Figure 1B) revealed a well-defined heterogeneous signal intensity lesion measuring about 1.8 × 1.7 × 2.1 cm seen diffusely in the midbrain tectum causing moderate obstructive hydrocephalus and IVH. Moreover, the digital subtraction angiogram was negative in two occasions suggestive of TC. A decision for surgery was taken to be conducted after stabilization of the patient condition. We conducted a suboccipital craniectomy with image-guided supracerebellar infratentorial approach for gross microscopic resection of the TC. Intraoperatively, a tuft of abnormal tiny vessels was seen surrounded by yellowish soft tissue. Histopathological analysis reported cauterized tissue with areas of hemorrhage, fibrin deposition, gliosis, and hemosiderin-laden macrophages and clusters of vessels confirming the TC diagnosis.

Postoperatively, the patient had an uneventful course and returned to preoperative baseline cognition and activity. However, he had upward gaze palsy and bilateral limitation of lateral gaze. Follow-up MRI

Table 1. Review of PubMed reported cases for solitary tectal cavernoma.

| Reference         | Case # | Sex | Age (y) | Clinical Presentation | Hemorrhage | Hydrocephalus | Lesion size (cm) | Surgical resection | Outcome          |
|-------------------|--------|-----|---------|-----------------------|------------|---------------|------------------|--------------------|-------------------|
| Girard et al., 1969 | 1      | F   | NA      | Coma                  | Yes        | No            | NA               | No                 | Death             |
| Sakai et al., 1991 | 2      | F   | 7       | Rt. hemiparesis, Abducent palsy, And altered consciousness | Yes        | Yes           | NA               | Yes                | Full recovery      |
| Zimmerman et al., 1991 | 3      | F   | 38      | Headache, vertigo, tinnitus, and Lt. sided paresthesia | Yes        | No            | 1.0              | Yes                | Full recovery      |
| Bertalanffi et al., 1991 | 4      | M   | 28      | Headache, nausea, and vomiting | Yes        | Yes           | 1.0              | Yes                | Full recovery      |
| 5                  | M      | 13  |         | Bilateral papilledema | NA         | Yes           | 1.0              | Yes                | Full recovery      |
| 6                  | F      | 38  |         | Headache, nausea, and vomiting | NA         | Yes           | 1.0              | Yes                | Full recovery      |
| Mizoi et al., 1992 | 7      | M   | 39      | Headache and Parinaud’s syndrome | Yes        | No            | 1.5              | Yes                | Full recovery      |
| Fritschi et al. 1994 | 8      | F   | 66      | Coma, hydrocephalus    | Yes        | Yes           | 1.0              | No                 | Full recovery      |
| 9                  | F      | 27  |         | Headache and coma      | No         | Yes           | 2.0              | No                 | Death             |
| 10                 | M      | 62  |         | Diplopia and hemiparesis | No         | No            | 1.0              | Yes                | Full recovery      |
| 11                 | F      | 45  |         | Diplopia, ataxia, vertigo, and seizures | Yes        | No            | 1.5              | Yes                | Persistent minimal neurological deficit |
| 12                 | F      | 38  |         | Headache and tinnitus  | Yes        | No            | 1.0              | Yes                | Full recovery      |
| 13                 | M      | 22  |         | Parinaud’s syndrome, coma | Yes        | No            | 0.6              | No                 | Death             |
| Duffau and Sichez, 1998 | 14     | M   | 63      | headache and diplopia  | Yes        | No            | 0.3              | Yes                | Full recovery      |
| Porter et al., 1999 | 15     | M   | 22      | NA                    | Yes        | NA            | NA               | No                 | Death             |
| Fujiwara et al., 2002 | 16     | M   | 30      | Headache and nausea    | No         | Yes           | NA               | Yes                | Transient upward gaze palsy |
| Cristini et al., 2004 | 17     | M   | 24      | Headache, drowsiness, Parinaud’s syndrome | No         | Yes           | 2.0              | Yes                | Persistent Memory disorder |
| Lizaro and Landeiro, 2006 | 18     | F   | 60      | Headache               | NA         | Yes           | NA               | Yes                | Full recovery      |
| Nayak et al., 2015 | 19     | F   | 39      | Headache, diplopia, Rt side paresthesia | Yes        | No            | 1.8              | Yes                | Partial recovery   |
| Aboul-Enen et al., 2015 | 20     | F   | 38      | Diplopia               | NA         | Yes           | NA               | Yes                | Transient upward gaze palsy |
| Januszewski et al., 2016 | 21     | M   | 18      | Parinaud’s syndrome    | Yes        | No            | 0.8              | Yes                | Full recovery      |
| 22                 | F      | 47  |         | Headache               | Yes        | No            | 1.1              | Yes                | Full recovery      |
| Carvalho et al., 2016 | 23     | F   | 60      | Headache, dizziness, and ataxia | NA         | NA            | NA               | Yes                | Persistent tremors |
| Nagoto et al., 2017 | 24     | M   | 77      | Quadriplegia and coma  | Yes        | Yes           | NA               | Yes                | Transient truncal ataxia |
| Al Barbarawi et al., 2022 | 25     | M   | 18      | Headache, convulsion, and Parinaud’s syndrome | Yes        | Yes           | 2.0              | Yes                | Full recovery      |
displayed a successful resection of the lesion (Figure 2). The patient demonstrated gradual improvement with regular postoperative follow-up visits, and after twelve weeks, he showed a significant improvement with better upward gazing and nearly no squint.

3. Methods

3.1. Literature review

A literature review of solitary TCs was conducted to study the epidemiologic and clinical features related to this condition, and to elucidate the main factors associated with the management outcomes in these patients. A PubMed search was performed to retrieve all cases of solitary tectal cavernoma reported over the last five decades. The following keywords and terms were used in the PubMed search: “tectal cavernoma,” “tectal cavernous malformation,” “tectal cavernous angioma,” “tectal angioma,” “tectal hemangioma.” However, secondary causes as tectal metastasis and cases with multiple lesions were excluded.

3.2. Statistical analyses

The factors that were investigated in relation to TC were described using frequency distribution for categorical variables and mean ± standard deviation for continuous variables. Pearson’s chi-square (χ²) tests were used to analyze the associations between categorical variables, and Student’s t-tests were used for continuous variables. A p < 0.05 was considered statistically significant. If a substantial association was found between categorical variables, a post-hoc residual analysis was then conducted to determine the exact significance in the contingency table.

4. Results

There have been 25 cases of isolated TC reported in the literature, including the current case (Table 1). A detailed summary of the patients is presented in Table 2. There was an equal male to female ratio (12:13). Most of the patients were adults (aged 18–77 y), except for two children (aged 7 and 13 y). The mean age of the patients was 38.3 ± 18.6 y. The lesion size ranged from 6.0 to 20 mm. The most common presenting complaints were headache (14 cases, 56%), altered level of consciousness (6 cases, 24%), and double vision (5 cases, ~21%). The symptoms were mainly due to or at least associated with a concurrent hemorrhagic lesion at presentation (16 cases, 64%). Around 60% of cases experienced two or more hemorrhagic episodes of the lesion (15/25). Parinaud’s Syndrome was present in five cases (20%) only (Table 2). Most of the cases (~79%) (15/19) who underwent surgical resection demonstrated gradual improvement until full recovery following the surgery. Postoperative morbidities were minimal (16%), and no postoperative mortality case was ever documented. Six patients did not undergo surgical resection and four of them ended up with death.

There were no sex variations in the presented patient symptoms or lesion characteristics, except for the presence of Parinaud’s Syndrome (Table 3). There was a significant association (p < 0.05) between the Parinaud’s Syndrome and patients’ sex since all patients who developed Parinaud’s Syndrome were males.

Regarding the outcome, there were no significant associations between Parinaud’s Syndrome, hemorrhage, or hydrocephalus from one side and the patients’ outcome from the other side (Table 4). Additionally, Pearson’s chi-square test of association revealed no significant association (p = 0.059) between the lesion size and the outcome; however, there was a significant (p = 0.034) likelihood ratio that the outcome could be expected from the lesion size. Furthermore, the post hoc residual analysis for the contingency table between the lesion size and the outcome showed that patients with lesion size between 1-10 mm have a higher-than-expected chance of full recovery (p < 0.05), while patients with lesion size between 11-20 mm have a higher-than-expected chance of developing a persistent deficit (p < 0.05) (Table 4).

Finally, there was a significant (p < 0.05) association between surgical resection and patient outcome, as patients who did not undergo surgical resection were more likely to end up with death.

| Associated factors | Number | Percent (%) |
|--------------------|--------|-------------|
| Total Patients     | 25     | 100.0       |
| Sex                |        |             |
| Male               | 12     | 48.0        |
| Female             | 13     | 52.0        |
| Age (y)            | 38.3 ± 18.6 |
| Patient Complaints |        |             |
| Headache           | 14     | 56.0        |
| Altered consciousness | 6   | 24.0        |
| Double vision      | 5      | 20.8        |
| Dizziness/Vertigo  | 4      | 16.0        |
| Nausea & vomiting  | 3      | 12.5        |
| Seizure/Convulsion | 2      | 8.0         |
| Tinnitus           | 2      | 8.0         |
| Hemiparesis        | 2      | 8.0         |

### Table 2. Summary for the PubMed reported cases of solitary tectal cavernoma.

| Lesion Size | Number | Percent (%) |
|-------------|--------|-------------|
| 1–10 mm     | 10     | 40.0        |
| 11–20 mm    | 7      | 28.0        |
| Unidentified| 8      | 32.0        |

### Table 4. Outcome of patients who underwent surgery.

| Outcome of patients who underwent surgery (Out of 19) | Full recovery | Transient deficit | Persistent deficit | Death |
|------------------------------------------------------|---------------|-------------------|-------------------|-------|
| No                                                   | 12            | 3                 | 4                 | 0     |

### Table 5. Outcome of patients who did not undergo surgery.

| Outcome of patients who did not undergo surgery (Out of 6) | Full recovery | Transient deficit | Persistent deficit | Death |
|----------------------------------------------------------|---------------|-------------------|-------------------|-------|
| No                                                       | 2             | 0                 | 0                 | 4     |

Abbreviations: mm, millimeter; SD, standard deviation; y, years.
Surgical Resection

Hemorrhage

Parinauds Syndrome

Age (y), mean ± SD 34.7 ± 21.1 41.9 ± 15.9 NS

Parinauds Syndrome

Yes 5 (100.0) NS
No 7 (35.0) 13 (65.0)

Hemorrhage

Yes 8 (50.0) 8 (50.0) NS
No 3 (75.0) 1 (25.0)

Hydrocephalus

Yes 6 (50.0) 6 (50.0) NS
No 5 (45.5) 6 (54.5)

Lesion Size

1–10 mm 6 (60.0) 4 (40.0) NS
11–20 mm 3 (42.9) 4 (57.1)

Surgical Resection

Yes 9 (47.4) 10 (52.6) NS
No 3 (50.0) 3 (50.0)

Outcome

Full recovery 7 (50.0) 7 (50.0) NS
Transient deficit 2 (66.7) 1 (33.3)
Persistent deficit 1 (25.0) 3 (75.0)
Death 2 (50.0) 2 (50.0)

Abbreviations: mm, millimeter; N, number; NS, not significant; p, probability; SD, standard deviation; y, years. 11(p < 0.01): significantly higher than expected frequency.

5. Discussion

In this communication, we report a unique case of a rare condition of midbrain TC causing recurrent IVH and Parinaud’s Syndrome. All the reported five cases of isolated TC with Parinaud’s Syndrome in literature were males. Indeed, several studies showed that Parinaud’s Syndrome, regardless of its cause, occurs in males more than females [9, 10, 11]. In all cases, MRI was the investigation of choice, and histopathology always confirmed the diagnosis.

Our patient sought emergency care after he had developed his first episode of symptomatic IVH as a result of a diffuse TC. Our patient then experienced the second episode of hemorrhage (rebleeding) after nine days of his first episode. Indeed, the annual risk of developing the first hemorrhagic episode of BSCs, including TCs, accounts for up to 6%, which is a relatively higher percentage than all ICCs [12]. The annual risk of developing the first hemorrhage in all ICCs accounts for up to 1.1% of all cases [13]. In addition, the annual risk of recurrent hemorrhages after the first episode in BSCs is remarkably very high (up to 60%) [12, 13]. Comparable to this fact, our review of the literature revealed that recurrent hemorrhage in TCs accounts for 60% of all reported cases.

The most common location for brainstem cavernoma is the pons, followed by the midbrain and medulla [14]. Brainstem cavernomas have a more aggressive course when compared with other central nervous system cavernomas due to either mass compression or hemorrhagic complications [15]. However, they are uncommon [16]. MRI scan is still the best imaging modality in the diagnosis of BSCs. It can also clearly demonstrate associated pathologies like perilesional edema, thrombus, or hemorrhage. Aggressive cavernoma can bleed from other causes like infection, hypertension, or coagulopathy, and all these causes can be affordable using MRI. The angiogram is usually negative [17].

The lesion size is considered a critical predictor of the outcome in different types of cancers [18, 19, 20]. The increase in tumor size has been associated with mass-related complications like compression and hemorrhage, and with higher invasion and metastasis rates in cases of malignancies [20, 21]. This will eventually result in more unfavorable management outcomes. Therefore, a large lesion size is considered a poor prognostic factor in the management of both benign and malignant types of cancers [22].

The management strategy of BSCs is controversial [23, 24]. Surgery may be considered in hemodynamically active cavernomas, recurrent bleeds, progressive neurologic deficits, significant mass effect, or progressive enlargement in the follow-up MRI. Due to the high rate of postoperative morbidity and mortality, surgical resection of brainstem cavernoma may be of great challenge for neurosurgeons. Postoperative complications could be reduced by appropriate surgical decision making, optimal surgical approach, careful surgical dissection, and the use of neuronavigation and electrophysiological monitoring [17]. Regarding TCs, specifically, our review showed that surgical resection was the ultimate management modality as 79% of all patients who underwent surgical removal ended up with full recovery, and two-thirds (66.7%) of the patients who did not perform surgery ended up with death. However, we believe that the management of BSCs must always be balanced by the risk-benefit profile of the patient and adapted to each case individually.

6. Conclusions

Solitary TC is a rare form of BSCs, with only few cases are reported in the literature. It is not associated with specific sex or a certain age. The most common complication associated with TC is hemorrhage (64%). Parinaud’s Syndrome is found in some cases, with its presence being male predominant. The lesion size and surgical resection are the only factors associated with the outcome of TCs. Larger lesions are more likely to lead to persistent deficits. Surgical resection is the ultimate management modality since most surgically treated cases end up with the complete recovery.

Declaration

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.
Funding statement

The article publishing charges were covered by a faculty grant to M. Z. Allouh from the College of Medicine and Health Sciences at the United Arab Emirates University, Al Ain, UAE (Grant # G00003395).

Ethical statement

This study was approved by the Institutional Review Board committee at Jordan University of Science and Technology (Approval # 18-136-2020). The study was conducted with the assurance of patient data confidentiality and in accordance with the Declaration of Helsinki and its later amendments for ethical research performance. The patient’s signed consent was obtained for this study.

Data availability statement

All data related to this work are included in the article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

References

[1] W.F. McCormick, The pathology of vascular (“arteriovenous”) malformations, J. Neurosurg. 24 (4) (1966 Apr) 807–816.
[2] S. Tsalimi, A. Modabbernia, S. Amin-Hanjani, F.G. Barker, R.L. Macdonald, Natural history of cavernous malformation: systematic review and meta-analysis of 25 studies, Neurology 86 (21) (2016 May 24) 1984–1991.
[3] R.T. Dalyai, G. Gobrial, I. Awad, S. Tjoumakaris, L.F. Gonzalez, A.S. Dumont, et al., Management of incidental cavernous malformations: a review, Neurosurg. Focus 31 (6) (2011 Dec) E5.
[4] V.A. D’Angelo, C. De Bonis, R. Amoroso, A. Cali, L. D’Agruma, V. Guarnieri, et al., Supratentorial cerebral cavernous malformations: clinical, surgical, and genetic involvement, Neurosurg. Focus 21 (1) (2006 Jul) e9.
[5] B.A. Gross, H.H. Batjer, I.A. Awad, B.R. Bendok, Brainstem cavernous malformations, Neurosurgery 64 (5) (2009 May) E805–E818, discussion E818.
[6] E.F. Hauck, S.L. Barnett, J.A. White, D. Samson, Symptomatic brainstem cavernomas, Neurosurgery 64 (1) (2009 Jan) 61–70, discussion 70–71.
[7] A. Cristini, C. Fischer, M. Sindou, Testal plate cavernoma-a special entity of brainstem cavernomas: case report, Surg. Neuro. 61 (5) (2004 May) 474–478, discussion 487.
[8] J.A. Frischi, H.J. Reden, R.F. Spetzler, J.M. Zahramski, Cavernous malformations of the brain stem. A review of 139 cases, Acta Neurochir. 130 (1–4) (1994) 35–46.
[9] N. Hura, A.-A.D. Vuppala, S. Sahraian, R. Milo, R. Huna-Baron, Parinaud syndrome: any clinicoradiological correlation? Acta Neuro. Scand. 136 (6) (2017 Dec) 721–726.
[10] M. Shields, S. Sinkar, W. Chan, J. Crompton, Parinaud syndrome: a 25-year (1991–2016) review of 40 consecutive adult cases, Acta Ophthalmol. 95 (6) (2017 Dec) e792–e795.
[11] O. Bozinov, T. Hatano, J. Sarnthein, J.-K. Burkhardt, H. Bertiand, Current clinical management of brainstem cavernomas, Swiss Med. Wkly. 140 (2010) w13120.
[12] R.W. Porter, P.W. Detwiler, R.F. Spetzler, M.T. Lawton, J.J. Baskin, P.T. Derksen, et al., Cavernous malformations of the brainstem: experience with 100 patients, J. Neurosurg. 90 (1) (1999 Jan) 50–58.
[13] A.M. Abunimer, A.M. Lak, H. Ahou-Al-Shaar, N.J. Patel, Anterior petrosectomy for resection of brainstem cavernous malformation, World Neurosurg. 135 (2020 Mar) 1–8.
[14] H. Li, Y. Ju, B. Cai, J. Chen, C. You, X. Hui, Experience of microsurgical treatment of brainstem cavernomas: report of 37 cases, Neuro. India 57 (3) (2009 Jun) 269–273.
[15] S.W. Jang, J.H. Park, H.J. Kwon, J.H. Yoon, Optimal cutoff values of primary tumour size to better predict long-term outcomes in patients with papillary thyroid carcinoma undergoing total thyroidectomy: a preliminary study using restricted cubic spline analysis, Clin. Endocrinol. (2021 Dec 15).
[16] H.H. Hsu, K.H. Ko, Y.C. Chou, W.C. Tsai, S.C. Lee, H. Chang, T.W. Huang, SUVmax and tumor size predict surgical outcome of synchronous multiple primary lung cancers, Medicine (Baltim.) 95 (6) (2016 Feb), e2351.
[17] A. El-Menyar, A. Mekkadi2hal, H. Al-Thani, Diagnosis and management of gastrointestinal stromal tumor: an up-to-date literature review, J. Cancer Res. Therapeut. 13 (6) (2017 Oct-Dec) 889–900.
[18] M. Kurucuoglu, A. Gokyer, O. Kula, A.C. Yekders, B.S. Sunal, Y.A. Karamustafaoglu, Y. Yoruk, I. Cicin, Relationship between the size and location of the mass and hiliar and mediastinal lymph node metastasis in early and locally advanced non-small cell lung cancer, J. Coll. Physicians Surg. Pak. 30 (2) (2020 Feb) 172–176.
[19] L. Zhou, W. Li, S. Cai, C. Yang, Y. Liu, Z. Lin, Large tumor size is a poor prognostic factor of gastric cancer with signet ring cell: results from the surveillance, epidemiology, and end results database, Medicine (Baltim.) 98 (40) (2019 Oct), e17367.
[20] D. Ding, Controversies in the management of brainstem cavernous malformations: role of stereotactic radiosurgery, Clin. Neurosurg. 131 (2015 Apr) 88–89.
[21] J. Yuen, P.C. Whitfield, Brainstem cavernous malformations - no longer a forbidden territory? A systematic review of recent literature, Neurochirurgie 66 (2) (2020 Apr) 116–126.