VIA MEDICA

CASE REPORT

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Severe course of radiation-induced meningioma — a new insight in screening for patients after radiotherapy?

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ABSTRACT

Meningiomas, being mostly benign tumours, are derived from the arachnoid cap cells. Their etiopathogenesis is based on various factors, including past radiation. The presented case of a 25-year-old patient, who developed a radiation-induced superior sagittal sinus meningioma based on his past head radiation distributed during acute lymphocytic leukaemia. The tumour's clinical image presented at first as headache, nausea, and dizziness, computer tomography and subsequently MRI were performed. The imaging examination revealed a very extensive, contrast-enhanced tumour mass located centrally on both sides and within the superior sagittal sinus. With the most likely diagnosis of parasagittal meningioma, the patient was qualified for tumour excision. The surgery was performed successfully resulting in maximal safe subtotal resection. After the surgery, the patient developed complications including hydrocephalus, which resulted in 5-months long hospitalization. The presented case illustrated the need for increased clinical attention in patients threatened by radiation (including radiotherapy), focused on possible head lesions.

Key words: meningioma, parasagittal meningioma, radiation-induced meningioma, radiotherapy, neurosurgery

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Introduction

Meningiomas are mostly benign tumours derived from the arachnoid cap cells, whose distribution along the entire neuroaxis reflects a broad spectrum of tumour localization. Based on the data collected on all primary brain tumours, these tumours account for about 37% of the lesions. Meningiomas are most found on the convexity (19% to 34%) and in parasagittal locations (18% to 25%), followed by the sphenoid wing and middle cranial fossa (17% to 25%), anterior skull base (10%), posterior fossa (9% to 15%), cerebellar convexity (5%) and clivus (< 1%) [1]. To optimize patient treatment and surgical outcomes, it is crucial to adjust the appropriate surgical targets and techniques depending on the location and biology of these neoplasms. The aetiology of sporadic meningiomas is not yet known. Many factors have been identified as possible causes of the development of intracranial meningiomas. These include head trauma, viral infections, deletion in the NF2 gene, the effect of cell phones, and sex hormones but regardless, the factor most strongly associated with meningioma formation is ionizing radiation [2, 3]. Such a high percentage of meningioma occurrence is made possible by the use of cranial radiotherapy, for example. A review study performed on a pool of 251 patients indicates a significant effect of radiation used during radiotherapy of primary lesions in the cranial region, suggesting performing

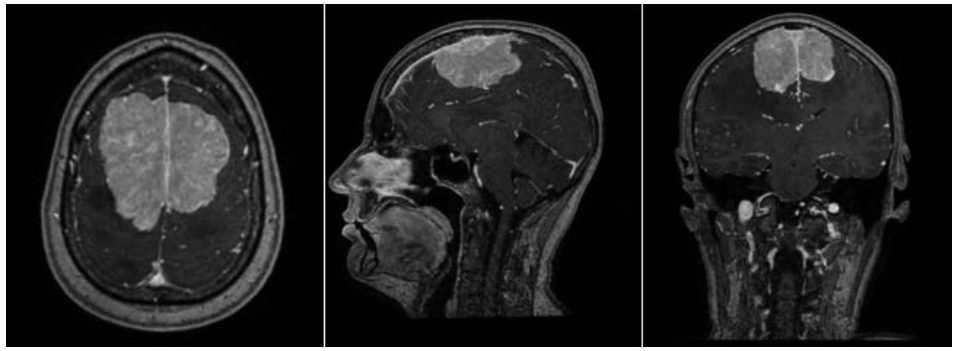

Figure 1. MRI scan in transverse (left), saggital (middle) and frontal (right) projection

long-term follow-ups of patients involved in this type of treatment [4]. They are more common in the older age group (incidence over age 85 years: 52.95 per 100,000 persons) and female patients (incidence: 11.25 per 100,000 females *vs.* 5.15 per 100,000 males). Five-year survival of patients with typical meningiomas exceeds 80% but decreases for malignant and atypical meningiomas. Among poor prognostic factors are large tumour sizes, deletions and loss of heterozygosity, high mitotic index, absence of progesterone receptors, and papillary and haemangiopericytic tumour morphology[1, 2, 5].

The meningioma described in this study is among those with an attachment to the dura that forms the outer layer of the superior sagittal sinus. Sagittal meningiomas are statistically detected more equally in both genders and are usually associated with mutations in the NF2 gene. In terms of development, they tend to be more aggressive than meningiomas in other locations. Differentiating them from convexity meningiomas is based on the presence of brain tissue at the parasagittal angle and attachment to the dura mater of the superior sagittal sinus, while falcine meningiomas can be distinguished by the presence of attachment to the falx cerebri. Symptoms may vary depending on the location of the parasagittal meningiomas but the most characteristic are focal neurological deficits, epilepsy, and increased intracranial pressure although headaches, depression, personality disorders, and burnout syndrome can also occur. The disappearance of symptoms to some extent or even completely is possible after surgery except in cases of elderly patients where the main symptom, among others, is dementia [1, 6].

To differentiate the meningioma's ability to infiltrate the interior of the sinuses, a 6-stage Sindou classification was created. The lesion characterized as type I is limited to the outer surface of the sinus wall. Type II lesion occurs when the tumour expands into a lateral recess of the SSS (superior sagittal sinus). If the tumour infiltrates into the lateral wall of the sinus it is referred to as type III. A lesion infiltrating the roof of the sinus is classified as type IV, while type V occurs when the entire sinus is occluded. Type VI is defined as a tumour that has completely crammed the sinus along with infiltration of all its walls [1, 6].

Case report

We would like to present the case of a 25-year-old patient admitted to the hospital for symptoms of elevated intracranial pressure, which manifested as headache, dizziness, and nausea. A CT scan of the head revealed that the cause of the complaints was a massive meningioma infiltrating the superior sagittal sinus, which was later confirmed by an MRI (Magnetic Resonance Imaging) scan (Fig. 1). The invasion was described in Sindou's classification as grade VI, meaning that the whole SSS was seized by the tumour. During childhood, the patient was treated with head radiotherapy for acute lymphoblastic leukaemia suggesting a connection with the present condition. Following the radiological diagnostics, it was decided to perform bilateral front-temporal-parietal craniotomy with the removal of meningioma infiltrating the SSS and resection of the front part of the sinus itself.

The neurosurgery was performed under general anaesthesia with the head fixed in place by the Mayfield frame in supination and its neutral position. Following the preparation of the surgical field, the skin was cut in a reversed U-shape with its base in the parietal area and AP dimension. After detachment of the musculocutaneous flap, six burr holes were drilled — two on each side in temporal areas and two on each side of the SSS, both in the front and back of it. Three burr holes located on the right side were joined using a craniotome. In the parasagittal area, the bone was very tightly connected with the wall of the SSS which required meticulous detachment. Subsequently, the 3 holes on the left side also were joined. The bone and

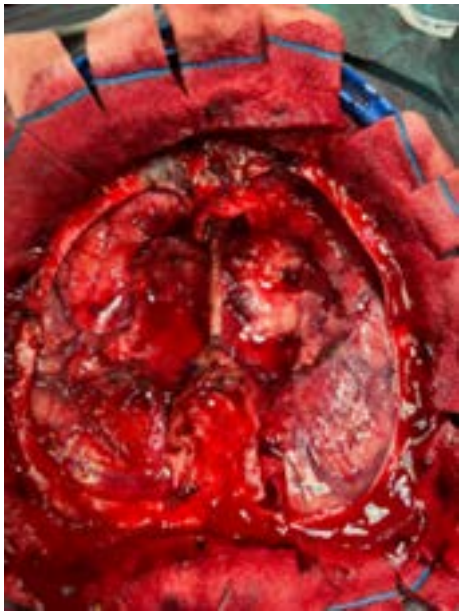

Figure 2. Intraoperative view on detached pericranium

dura mater were separated using a dissector and guide. After the removal of the bone flap, it was necessary to manage the bleeding from the SSS which was stopped with a flake of fibrin sealant patch. Then, the dura mater was cut in a semi-circular shape, on both sides and with its bases directed toward the sinus. Using the dissector, the dura mater was separated from the tumour of a bluish-purple appearance. The meningioma was detached with the usage of a dissector and separated from the normal tissues using cotton wool with saline while some small vessels were coagulated during the process. After exposing the tumour it was necessary to devascularize it by cutting and coagulating the vessels nourishing the meningioma. The tumour on the right side was removed in a few pieces and under microscopic magnification, leaving only a small part at the falx cerebri. Afterwards, the same procedure was done on the opposite side. Then, based on the earlier performed Computed Tomography Angiography, which showed the total infiltration of the frontal part of the SSS, a decision was made to also remove a large part of the sinus and the neoplastic tissue that penetrated it. The SSS was ligated with a few sutures at its front part and the infiltration of the sinus by the tumour was confirmed. A similar procedure was performed on the rear part of the sinus, ahead of the big collateral vein. Then, the massive fragment of SSS with fragments of the tumour was removed. The wall of the falx cerebri was coagulated with a monopolar electrode while using a thrombin solution for haemostasis. Subsequently, the pericranium was detached from the musculocutaneous flap (Fig. 2).

After attaining the approvable haemostasis, the pericranial patch was stitched into the defect of the dura mater, making it watertight and additionally sealing it with a fibrin sealant patch. Next, the meninx was suspended in many places with Dandy's and Poppen's sutures and then the bone flap was fixed in its original place with the usage of a titanium clamp system. The drainage was left in the place of surgery and the skin was stitched with layered closure.

After the surgery, initially, the patient recovered well. The control contrast-enhanced MRI showed a satisfactory tumour removal with a small remnant of the neoplastic tissue in front of a collateral vein that connects superior and inferior superior sagittal sinuses.

During hospitalization, the patient underwent ventriculoperitoneal valve implantation, which was later removed due to inflammatory complications and peritonitis. It led to the need for a laparotomy intended to remove the peritoneal abscess. Subsequently, a meningeal reconstitution was performed twice. During the procedure, the site of the leak was not visualized. The meninges were covered with haemostatic materials, which failed to yield a clinical improvement. During the last meningeal reconstitution, the craniectomy flap, which was believed to have become infected, was removed. After obtaining negative microbiological cultures, a ventriculoarterial valve was inserted into the angular vein navigating the narrow ventricles of the brain.

Currently, the wound is healed, with no signs of fluid loss. The patient was discharged home after 5 months of hospitalization.

Discussion

Acute lymphoblastic leukaemia (ALL) is the most common paediatric cancer. In the United States, approximately 5,930 cases of ALL were newly diagnosed, and nearly 1,500 patients died from ALL in 2019. The global incidence of ALL increased from 1990 to 2019 by 30.81% [7]. One of the therapeutic options for treating ALL is head radiotherapy, in which adverse events include carcinogenesis.

The occurrence of meningioma among ALL radiotherapy receivers, after 25 years of follow-up, was estimated in one single-centre study as 21.4%, whereas the presence of neurological symptoms caused by brain lesions was 16.0%. However, the incidence appears to be significant, the idea of screening MRI among post-radiotherapy patients was rejected by the article authors because usual clinical symptoms appear at the early stage of meningioma [8], although other authors suggest a requirement of such a screening program [9]. Another study, based on victims of the nuclear bombing in Hiroshima, estimates the occurrence of meningioma as 14.9% after a 20-year follow-up [10]. In the presented

case, the existence of symptoms (headache, nausea, dizziness) was linked with the sizable dimension of the lesion and its high grade in the Sindou classification, so a more recent MRI of this patient would potentially lead to a less-burdening surgical intervention. On the other hand, irradiation was classified as one of two (next to cyclophosphamide exposure, of which occurrence isn't confirmed in the presented case) main causes of secondary brain tumours in post-ALL patients [11]. This data, combined with the presented case, may suggest the need to reconsider a screening program for secondary brain tumours among patients following those types of therapy, and other groups exposed to radiation. Especially according to the severe course of meningioma (including post-operative complications) in the presented case.

To put this information into perspective one should recognize that radiation appears to be responsible for from 7.8 to 31.4% of all paediatric meningiomas [12, 13]. Paradoxically, radiation-induced meningiomas tend to come along with a better prognosis, in comparison to non-radiation-related ones — a single-centre study showed that none of the included patients with radiation-induced meningioma developed progression of the tumour, in contrast to meningiomas with different etiopathogenesis. The reason appointed by this study's authors includes a correlation between the younger diagnosis of meningioma and higher risk of progression, and statistically higher age of diagnosis in patients with radiation-induced meningiomas (average age 17.3 ± 3.5 years *vs.* 10.7 ± 5.7 years for non-radiation-related) [13]. According to mentioned correlation, the risk of progression in the presented patient should be considered to be very low according to his relatively late age of diagnosis (25 years). The other factor, which is described as prognostic for meningioma progression, is the high expression of MIB-1 antigen in immunohistochemical staining[14], which unfortunately wasn't performed in the presented case. When mentioning immunohistochemical staining, it should be noted that 1–10% of meningiomas may occur as multiple lesions, and this group has significantly different antigen descriptions — but the existence of radiation-induced multiple meningiomas wasn't described until now even in a single case report[15].

Although meningioma is the most common post-radiation tumour of the head, accounting for approximately 44–52% of them [16, 17], it isn't the only one that may develop as a result of radiotherapy. According to scientific literature, this group of post-radiation head lesions include also sarcoma [16], especially Ewing sarcoma [17], malignant astrocytoma [16], medulloblastoma [16], haemangioma [18], glioma [18, 19], germ cell tumour [17], malignant parotid gland tumour [17] and rhabdomyosarcoma [19, 20]. A single case report also showed patients with various head tumours coexistence: meningioma + angioma [21], meningioma + pituitary adenoma [22], meningioma + subependymoma + cavernoma [23], or meningioma + pituicytoma (hormonally inactive) + cavernoma [24].

Although the superior sagittal sinus is one of the most common sites of this lesion, it still only constitutes 10.7–16.9% of all meningiomas [25]. The first disparity of SSS meningiomas is the significantly later age of diagnosis — 57 years on average — in comparison to meningiomas in general [26]. Additionally, the proximity of bone structures may result in meningioma invasion of scalp bones [27], and even subcutaneous tissue of the head [28]. This ruinous process may result in the requirement of reconstruction, but there is a case reporting a recurrence of meningioma through titanium-based cranioplasty [29]. On the other hand, there are reported cases of hyperostosis in the case of meningioma [28, 30]. Nevertheless, those radical complications appear to exist rarely, and the most common structure threatened by meningioma invasion is dura mater [26].

According to the novel surgical techniques, gamma knife radiosurgery provides an interesting alternative and was reported in many cases of SSS meningioma in up-to-date literature [31, 32]. However, in such an advanced stage of disease, classical surgery appeared to be the most appropriate approach.

In conclusion, clinical attention should be paid to every patient who had radiotherapy in their clinical past. However, usually, a radiation-induced meningioma is easy to cure and has a mild course, although, in some cases (like the presented) postoperative complications may be aggravating. The presented case may be considered a new insight into the idea of screening MRI in patients after radiotherapy.

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References

1. Quinones-Hinojosa A. Schmidek and Sweet: Operative Neurosurgical Techniques. 7th edition. Elsevier, Cambridge 2021.
2. Marosi C, Hassler M, Roessler K, et al. Meningioma. Crit Rev Oncol Hematol. 2008; 67(2): 153–171, doi: 10.1016/j.critrevonc.2008.01.010.
3. Gałązka J, Homa P, Domagalski Ł. endocrine background of meningioma carcinogenesis. J Educ Health Sport. 2022; 13(2): 196–200, doi: 10.12775/jehs.2023.13.02.028.
4. Yamanaka R, Hayano A, Kanayama T. Radiation-induced meningiomas: an exhaustive review of the literature. World Neurosurg. 2017; 97: 635–644.e8, doi: 10.1016/j.wneu.2016.09.094, indexed in Pubmed: 27713063.
5. Gatson NaT, Boccia ML, Taylor KR, et al. Hormone-Dependent tumors and sexuality in the neuro-oncology of women (N.O.W.): women's brain tumors, gaps in sexuality considerations, and a need for evi-

dence-based guidelines. Curr Oncol Rep. 2021; 23(11): 127, doi: 10.1007/s11912-021-01115-w, indexed in Pubmed: 34453233.
6. Mathiesen T. Parasagittal meningiomas. Handb Clin Neurol. 2020; 170: 93–100, doi: 10.1016/b978-0-12-822198-3.00031-8, indexed in Pubmed: 32586512.
7. Yi M, Zhou L, Li A, et al. Global burden and trend of acute lymphoblastic leukemia from 1990 to 2017. Aging (Albany NY). 2020; 12(22): 22869–22891, doi: 10.18632/aging.103982, indexed in Pubmed: 33203796.
8. Co JL, Swain M, Murray LJ, et al. Meningioma screening with MRI in childhood leukemia survivors treated with cranial radiation. Int J Radiat Oncol Biol Phys. 2019; 104(3): 640–643, doi: 10.1016/j.ijrobp.2019.02.057, indexed in Pubmed: 30880270.
9. Oda K, Sato T, Watanabe T, et al. Radiation-induced World Health Organization grade II meningiomas in young patients following prophylactic cranial irradiation for acute lymphoblastic leukemia in childhood. Three case reports. Neurol Med Chir (Tokyo). 2012; 52(4): 224–228, doi: 10.2176/nmc.52.224, indexed in Pubmed: 22522336.
10. Shintani T, Hayakawa N, Hoshi M, et al. High incidence of meningioma among Hiroshima atomic bomb survivors. J Radiat Res. 1999; 40(1): 49–57, doi: 10.1269/jrr.40.49, indexed in Pubmed: 10408177.
11. Schmiegelow K, Levinsen MF, Attarbaschi A, et al. Second malignant neoplasms after treatment of childhood acute lymphoblastic leukemia. J Clin Oncol. 2013; 31(19): 2469–2476, doi: 10.1200/JCO.2012.47.0500, indexed in Pubmed: 23690411.
12. Grossbach AJ, Mahaney KB, Menezes AH. Pediatric meningiomas: 65-year experience at a single institution. J Neurosurg Pediatr. 2017; 20(1): 42–50, doi: 10.3171/2017.2.PEDS16497, indexed in Pubmed: 28474981.
13. Fouda MA, Day EL, Zurakowski D, et al. Predictors of progression in radiation-induced versus nonradiation-induced pediatric meningiomas: a large single-institution surgical experience. J Neurosurg Pediatr. 2021 [Epub ahead of print]: 1–7, doi: 10.3171/2021.1.PEDS20819, indexed in Pubmed: 34116509.
14. Vranic A. Antigen expression on recurrent meningioma cells. Radiol Oncol. 2010; 44(2): 107–112, doi: 10.2478/v10019-010-0028-6, indexed in Pubmed: 22933900.
15. Vikmane B, Jakovlevs A, Vanags A, et al. Solitary and multiple meningiomas: an immunohistochemical comparison. Acta Chirurgica Latviensis. 2015; 15(1): 23–28, doi: 10.1515/chilat-2016-0005.
16. Chowdhary A, Spence AM, Sales L, et al. Radiation associated tumors following therapeutic cranial radiation. Surg Neurol Int. 2012; 3: 48, doi: 10.4103/2152-7806.96068, indexed in Pubmed: 22629485.
17. Ueda T, Migita M, Itabashi T, et al. Therapy-related secondary malignancy after treatment of childhood malignancy: cases from a single center. J Nippon Med Sch. 2019; 86(4): 207–214, doi: 10.1272/jnms.JNMS.2018_86-401, indexed in Pubmed: 31061250.
18. Cabaj A, Bekiesińska-Figatowska M, Duczkowska A, et al. Brain MRI findings in neurological complications of cancer treatment. Adv Clin Exp Med. 2016; 25(4): 789–797, doi: 10.17219/acem/37716, indexed in Pubmed: 27629856.
19. Kantar M, Cetingül N, Kansoy S, et al. Radiotherapy-induced secondary cranial neoplasms in children. Childs Nerv Syst. 2004; 20(1): 46–49, doi: 10.1007/s00381-003-0798-x, indexed in Pubmed: 14714135.
20. Rivero-Garvía M, Márquez-Rivas J, Rivas E, et al. Primary cerebral radiotherapy-induced rhabdomyosarcoma: treatment with intraoperative carmustine implants. Pediatr Hematol Oncol. 2013; 30(1): 1–3, doi: 10.3109/08880018.2012.737440, indexed in Pubmed: 23140336.
21. Baheti AD, Mahore AS, Zade BP, et al. Meningioma and cavernous angioma following childhood radiotherapy. J Cancer Res Ther. 2010; 6(3): 333–335, doi: 10.4103/0973-1482.73348, indexed in Pubmed: 21119268.
22. Gosal JS, Shukla K, Praneeth K, et al. Coexistent pituitary adenoma and frontal convexity meningioma with frontal sinus invasion: A rare association. Surg Neurol Int. 2020; 11: 270, doi: 10.25259/SNI_164_2020, indexed in Pubmed: 33033632.
23. Narro-Donate JM, Velasco-Albendea FJ, García-Pérez F, et al. Different radioinducid tumors synchrony in an acute lymphoblastic leukemia survivor. Neurocirugia (Engl Ed). 2020; 32(5): S1130–1473(20)30101-9, doi: 10.1016/j.neucir.2020.07.003, indexed in Pubmed: 33012645.
24. Chester AN, Tan CH, Muthurajah V, et al. Concurrent pituicytoma, meningioma, and cavernomas after cranial irradiation for childhood acute lymphoblastic leukemia. World Neurosurg. 2020; 136: 28–31, doi: 10.1016/j.wneu.2019.12.144, indexed in Pubmed: 31904435.
25. Hirayama R, Kinoshita M, Arita H, et al. Voxel-based lesion mapping of meningioma: a comprehensive lesion location mapping of 260 lesions. J Neurosurg. 2018; 128(6): 1707–1712, doi: 10.3171/2017.3.JNS17169, indexed in Pubmed: 28862550.
26. Caroli E, Orlando ER, Mastronardi L, et al. Meningiomas infiltrating the superior sagittal sinus: surgical considerations of 328 cases. Neurosurg Rev. 2006; 29(3): 236–241, doi: 10.1007/s10143-006-0020-1, indexed in Pubmed: 16607555.
27. Velnar T, Pregelj R, Limbaeck-Stokin C. Brain meningioma invading and destructing the skull bone: replacement of the missing bone in vivo. Radiol Oncol. 2011; 45(4): 304–309, doi: 10.2478/v10019-011-0036-1, indexed in Pubmed: 22933971.
28. Sasaki K, Saito A, Nishijima Y, et al. Giant intraosseous meningioma associated with calvarial hyperostosis and subcutaneous invasion: case reports and literature review. Asian J Neurosurg. 2021; 16(3): 589–594, doi: 10.4103/ajns.AJNS_534_20, indexed in Pubmed: 34660375.
29. Valente Aguiar P, Gonçalves M, Vaz R, et al. A rare case of meningioma recurrence on a titanium mesh cranioplasty. Br J Neurosurg. 2021 [Epub ahead of print]: 1–4, doi: 10.1080/02688697.2021.1995592, indexed in Pubmed: 34726561.
30. Songdej N. Focal cranial hyperostosis from meningioma: a complication from previous radiation treatment for childhood T-cell acute lymphoblastic leukemia. J Pediatr Hematol Oncol. 2014; 36(2): 148–149, doi: 10.1097/MPH.0b013e3182830d56, indexed in Pubmed: 23459379.
31. Nwachuku E, Duehr J, Pease MW, et al. Successful management of an intraluminal superior sagittal sinus meningioma causing elevated intracranial pressure using gamma knife radiosurgery in subacute setting: A case report. Surg Neurol Int. 2021; 12: 86, doi: 10.25259/SNI_562_2020, indexed in Pubmed: 33767890.
32. Ene CI, Kurnik N, Vellimana AK, et al. Microsurgical resection of a primary intraosseous meningioma encasing the superior sagittal sinus. J Craniofac Surg. 2020; 31(7): 2012–2014, doi: 10.1097/SCS.0000000000006701, indexed in Pubmed: 32657980.