Coexistence of craniopharyngioma and meningioma
Two rare cases and literature review

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Abstract
Most of the craniopharyngioma is considered to derive from residual epithelial cells during the craniopharyngeal canal degeneration. Meningioma accounting for the primary intracranial neoplasm is considered to be mainly derived from cells of arachnoid granulations. Nevertheless, rare cases show coexistence of craniopharyngioma and meningioma.

Case 1: A 43-year-old male patient referred to the hospital due to paroxysmal headache combined with blurred vision for 1 month. On physical examination, the visual acuity of left eye was poorer than that of the right eye. The visual acuity of the right eye near the nasal part showed defect.

MRI and pathological examination were performed. The patient received intracranial tumor resection. After surgery, the patient showed hormone disorder, followed by corresponding treatment. However, the patient was lost in the 6-month follow-up.

Case 2: The 64-year-old male patient presented to our department due to decline of visual acuity within 1 year combined with polydipsia (5,000 ml per day), polyuria and fatigue for 6 months. On physical examination, the bilateral visual acuity showed decline, especially the temporal part which was nearly hemiscotosis. MRI was performed. The adamantinomatous craniopharyngioma was diagnosed with the HE staining findings. The patient received intracranial resection. After surgery, the patient was in a deep coma condition, and was lost in the follow-up.

In this case study, we presented 2 patients with coexistence of craniopharyngioma and meningioma. In addition, a complete literature review was carried out to illustrate the studies on coexistence of craniopharyngioma and meningioma. Meanwhile, we tried to explain the possible mechanisms for such condition.

Abbreviations: CNS = central nervous system, MRI = magnetic resonance imaging.

Keywords: collision tumor, craniopharyngioma, intracalvarium, meningioma

1. Introduction

Craniopharyngioma is a rare benign tumor with central nervous system (CNS) involvement. Meningioma is a common

tumor of CNS[1] presenting different MRI findings and pathological features. Coexistence of intracranial craniopharyngioma and meningioma, with an extremely lower prevalence, is a type of collision tumor that may be associated with the chemoradiation, embryogenic development and induction factors.[2] In this study, we analyzed the MRI findings and the pathological subtypes of 2 cases with coexistence of intracranial craniopharyngioma and meningioma. Meanwhile, a comprehensive literature research was performed. We aim to enhance our understanding on such type of collision tumor.

2. Case report

2.1. Case 1

A 43-year-old male patient referred to our hospital due to paroxysmal headache combined with blurred vision for 1 month. On physical examination, the visual acuity of left eye was poorer than that of the right eye. The visual acuity of the right eye near the nasal part showed defect. He reported no history of radiation, chemical exposure and trauma. Before surgery, the level of hormone was not available.

For the MRI findings of craniopharyngioma, there was a nodule ($1.8 \times 2.5 \times 2.1$ cm) in the saddle with an irregular shape. There were mixed T1 equal hypointensity signals, and the signals for T2 were mainly equal intensity signals combined with few high intensity signals. Significant and uneven enhancement was noticed after administration of Gd-DTPA. The meningioma was
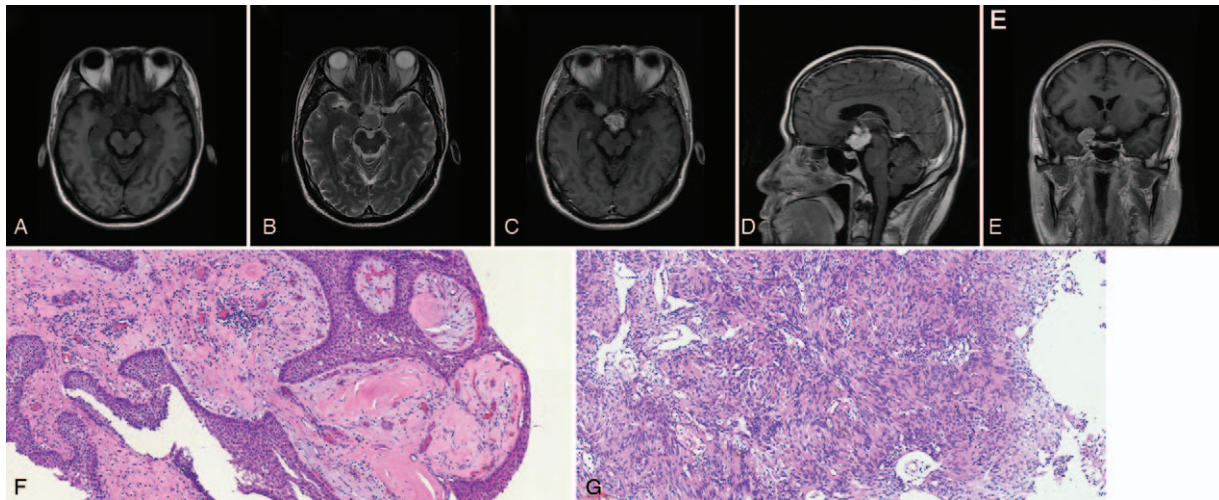
Figure 1. Imaging findings for the adamantinous type craniopharyngioma in the suprasellar region and meningothelial meninges in the right sphenoidal crest. (A) Cranial MRI scan, T1WI, transverse view; (B) T2WI, transverse view; (C) T1WI + C, transverse view; (D) T1WI + C, sagittal view; (E) Coronary view; (f, g) HE staining for the craniopharyngioma and meningioma, under a magnification of 200 ×.

localized at the right sphenoidal crest with a size of $1.5 \times 1.0 \times 1.1$ cm. The T1 signals were even and equal, while T2 signals were slightly lower and even. Upon administration of Gd-DTPA, significant and even enhancement was noticed, together with tail signs in the meninges (Fig. 1A-E).

For the pathological findings, the craniopharyngioma (Fig. 1F) was adamantinomatous craniopharyngioma, which was classified into grade I according to the WHO classification.[1] The columnar cells in a cube or column pattern were arranged in a palisade profile, which was similar to the adamantoblasts in structure. The middle layer was pavement epithelium cells presenting a polygonal profile. There were sparse cells in a stellate profile in the internal layer. There was island like keratinization.

The meningioma (Fig. 1G) was meningothelial meningioma, and was of grade I according to the WHO classification. The tumor cells was well differentiated. The kytoplasm was of acidophilia. The boundary was vague. There were few karyokinesis. Part of the cancer cells presented close swirl.

The patient received intracranial tumor resection after general anesthesia using intravenous injection of Midazolam (4 mg), Propofol (6 ml), Sufentanil (50 μg), and cis-Tracurum (55 mg), together with minipumping of Remifentanil (2 mg) and propofol (100 ml). The craniopharyngioma was mainly localized at the saddle area, and protruded to the posterior part. The tumor was in a grey-yellow color with uneven texture. There were no obvious cystic lesions. The tumor was adhered to the pituitary stalk, and was closely adjacent to the optic nerves and optic chiasma with no obvious boundaries. The meningioma was localized at the right sphenoidal crest, and the boundary was clear with an envelop. After surgery, the patient showed hormone disorder, followed by corresponding treatment. However, the patient was lost in the 6-month follow-up.

2.2. Case 2

The 64-year-old male patient presented to our department due to decline of visual acuity within 1 year combined with polydipsia (5000 ml per day), polyuria and fatigue for 6 months. On physical examination, the bilateral visual acuity showed decline, especially the temporal part which was nearly hemiscotosis. He reported no history of radiation, chemical exposure and trauma. The hormone levels were as follows: adrenocorticotropic hormone, < 5.00 ng/l (4.8–48.8 ng/l); testosterone, 0.13nmol/L (4.94–32.01nmol/L); prolactin, 30.65 ng/ml (3.46–19.40 ng/ml); progesterone, 0.2 ng/ml (<0.1–0.2 ng/ml); estradiol, < 10.00pg/ml (11–44pg/ml); follicle stimulating hormone, 0.67mIU/ml (0.95–11.95mIU/ml).

For the MRI findings (Fig. 2A-C), there was a cystic/solid nodule in the saddle and the third ventricle. The shape was not regular, which showed a size of $2.0 \times 2.9 \times 2.6$ cm. Equal T1 signals and high T2 signals were observed in the cystic lesions. Slightly high T1 signals, together with mixed densities of T2 signals, were noticed in the solid lesions. Upon administration of Gd-DTPA, there was obvious enhancement at the margins of the solid and cystic lesions, and the enhancement was not even.

For the meningioma, there was a nodule in the right olfactory sulcus with a size of 1.5×1.0 cm. There were slightly high T1 signals, and few equal signals were observed at the central part. Upon administration of Gd-DTPA, there was obvious enhancement. The enhancement was even.

For the HE staining findings of craniopharyngioma (Fig. 2D), adamantinomatous craniopharyngioma was diagnosed. The columnar cells showed palisade arrangement, which formed the basal layer. The intermediate layer was pavement epithelium cell. The internal layer was sparse reticular cells, together with infiltration of inflammatory cells.

The cancer cells of meningioma (Fig. 2E) were of meningothelial type in meninges, of WHO grade I. The nucleus of cancer cells was in a round or ellipse profile. The boundary was not clear, and the cells were well differentiated. Few cells showed phases of karyokinesis. The tumor cells showed a nest or lobulated growth. Partial cells showed arrangement in a swirl pattern, which were separated by the connective tissues containing blood vessels. Psammoma bodies were noticed.

The patient received intracranial resection after general anesthesia. The craniopharyngioma was localized beneath the third ventricle close to the saddle area in a grey color. The texture was slightly soft, and the blood supply was normal. The cystic
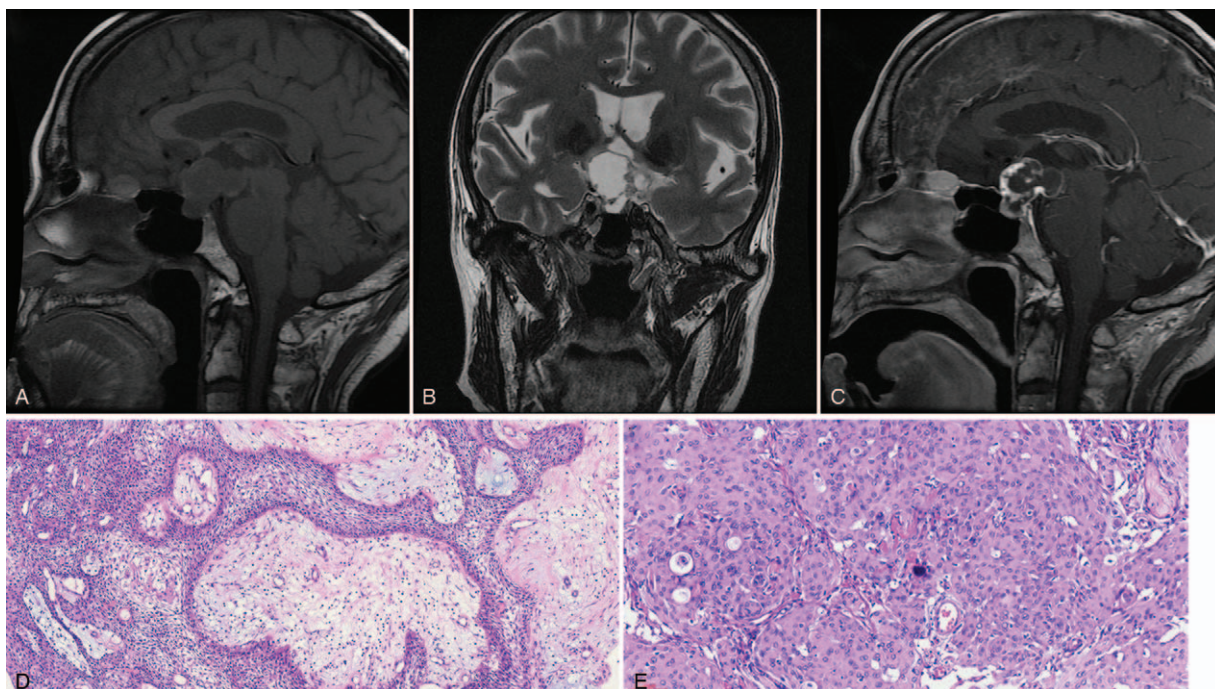
Figure 2. Imaging findings for the suprasellar region, adamantinous type craniopharyngioma in the third ventricle, and meningothelial meninges in the right olfactory sulcus. (A) Suprasellar region MRI scan, T1WI, sagittal view; (B) T2WI, coronal view; (C), T1WI+C, sagittal view. (D,E) HE staining for the craniopharyngioma and meningioma, under a magnification of 200×.

lesions were noted. The tumor was adjacent to the third ventricle and hypothalamus. The meningioma was localized at the left olfactory sulcus. It was in a pink color, with hard texture. The blood supply was abundant, and the basement was localized in the olfactory sulcus, which protruded the left olfactory nerve outwards. The dura mater near the olfactory sulcus was hampered by the cancer tissues, and part of the bone absorption showed decrease. After surgery, the patient was in a deep coma condition, and was lost in the follow-up.

3. Discussion

Craniopharyngioma is a rare cranial tumor, with a prevalence of about 3% to 6% in China mainland,[3] and meningioma is a common CNS tumors. In the CNS tumor proposed by the WHO in 2016,[1] the craniopharyngioma was classified into grade I consisting of adamantinomatous craniopharyngioma and papillary craniopharyngioma, while the meningioma was classified into grade I-III. WHO classification of tumors of CNS in 2016 provides 15 distinct variants of meningioma of which nine variants correspond to WHO grade I, 3 variants correspond to WHO grade II, while other 3 variants correspond to the malignant type of WHO grade III meningiomas. This classification is based on growth pattern, mitotic index and brain invasion. To our best knowledge, rare cases simultaneously present these 2 tumors. There were only 6 cases between 1967 and 2018 in our literature research.[4–9] In this study, we presented 2 more cases with collision of craniopharyngioma (adamantinomatous craniopharyngioma) and meningioma (meningothelial meningioma).

Presence of at least 2 types of tumors in one cranial position was defined as coexisting tumor. It is really rare in the fields of neurosurgery.[9] Nowadays, 2 mechanisms are reported to explain this phenomenon, including:

1. tumor-tumor metastasis, defined as metastasis of cancer cells to another cancer. In addition, 2 of the following criteria[10] must be met: (a) the pathological findings were that the donor metastasis must be partially enclosed by a recipient benign primary neoplasm of the brain; (b) the metastatic neoplasm must originate from a known primary carcinoma.
2. Collision tumor, defined as coexistence of 2 primary tumors in one anatomical site. The 2 tumors may mutually contribute to the pathogenesis of each other.[11]

In a recent study, intracranial collision tumor accounted about one third of the coexistence tumor in skull.[2] According to the previous description,[12] the pathogenesis of collision tumor may be associated with the following aspects:

1. two tumors occurred at the same position or adjacent locations;
2. tumors occurred at the same position of the different tissues due to radiation, chemical exposure and trauma;
3. cranial tumor induced different tissue-derived tumor in the peripheral cerebral parenchyma or meningeal tissues;
4. the residual embryonic structure finally developed into different tissue-derived tumor.

Given the hyper-vascularization and relatively high incidence, meningioma is the most commonly implicated intracranial neoplasms in both metastasis and collision tumors.[6,13,14] In this study, a comprehensive analysis was performed for the collected cases (including the 2 cases in this study). As shown in Table 1, 3 cases showed collision tumor of no pathological subtype, 5 with adamantinomatous craniopharyngioma, 1 with meningioma of the transitional meningioma, 1 with angiomatous meningioma, 2 with meningothelial meningioma and 1 of uncertain type. All the 7 cases showed no histories of radiation,

Table 1

Clinopathological features of the 8 cases.

Case	Age (yrs)	Gender	Radiation, chemical exposure and trauma	Preoperative hormone	Craniopharyngioma Position	Craniopharyngioma Pathological type	Meningioma Position	Meningioma Pathological type	Prognosis	Reference
1	54	Female	Not available	Not available	Third ventricle	None	In the peripheral parts of the left frontal sinus	None	Died before surgery	[4]
2	65	Male	None	Not available	Suprasellar region-third ventricle	None	Anterior clinoid process	None	Alive	[5]
3	61	Female	None	Not available	Suprasellar region-third ventricle	None	Tuberculum sellae	None	Died, postoperative 10 days	[6]
4	81	Female	None	Adrenocorticotropic hormone, 17ng/l[10–50]; corticosteroid, 397nmol/l[138–690]; follicle-stimulating hormone, 29.7U/l[35–150]; luteinizing hormone, 28.9U/l[11–61.5]	Anterior border of pituitary gland, intra-sellar region-suprasellar region	Adamantinomatous type	Anterior skull base	transitional type	Alive	[7]
5	57	Male	None	Testosterone, 3.21ng/ml (4.30–25.56); corticosteroid, 31.40ng/ml (50–250)	Suprasellar region	Adamantinomatous type	Anterior skull base	Angiomatous meningioma type	Alive	[8]
6	68	Male	None	Lactotropin 557.2 mIU/L (86.0~324.0 mIU/L); adrenocorticotropic hormone, 73.69 pg/mL (7.30~63.29 pg/mL); testosterone, <0.09 nmol/L (9.90~27.80 nmol/L); estradiol, <18.35 pmol/L (99.40~192.00 pmol/L)	Suprasellar region	Adamantinomatous type	Right cavernous sinus	None	Alive	[9]
7	43	Male	None	Not available	Suprasellar region	Adamantinomatous type	Right sphenoidal crest	Meningothelial type	Postoperative hormonal disorder, lost in the 6-month follow-up	Case 1
8	67	Male	None	Adrenocorticotropic hormone, <5.00ng/l (4.8–48.8); testosterone, 0.13nmol/L (4.94–32.01); Prolactin, 30.65ng/ml (3.46–19.40); progesterone, 0.2ng/ml (<0.1–0.2); estradiol, <10.00pg/ml (11–44); follicle-stimulating hormone, 0.67 mIU/ml (0.95–11.95); luteinizing hormone, 0.02 mIU/ml (1.14–8.75); corticosteroid, 32.5 nmol/L (8:00am 101.2–535.7, 4:00pm 79–477.8)	Intra-sellar region-suprasellar region-third ventricle	Adamantinomatous type	Left olfactory sulcus	Meningothelial type	Deep coma after surgery, lost in the follow-up	Case 2

chemical exposure and trauma. One case showed no information available. Four cases showed no hormone level information before disease onset. Four cases showed hormonal disorder. At first, these 2 aspects occurred in different sites in skull, with no direct adhesion. Pathological findings indicated no interaction between craniopharyngioma and meningioma as they were independent from each other. Besides, there was no partial enclose between the tumors. Therefore, their coexistence may not be associated with tumor-tumor metastasis, and the 2 cancers were collision tumor. Before disease onset, the patient underwent no radiation and chemical exposure. Besides, there was no trauma. Thus, the possibility was excluded. For the origin of craniopharyngioma, the embryonal-rest hypothesis has been well acknowledged to explain its pathogenesis,[15] but the meningioma must be originated from the arachnoid granulations.[16] Therefore, it is not possible for the residual embryonic structure to develop into different tissue-derived tumors. Craniopharyngioma usually leads to hormonal disorder mediated by pituitary gland injury.[17–19] It is now well-documented that meningiomas have endogenous and exogenous sex hormonal susceptibility.[20–22] Three patients presented hormonal disorder, and 4 cases showed craniopharyngioma of adamantinomatous type. The meningioma showed different types. We speculated that the collision of craniopharyngioma and meningioma may be associated with the different tissue-derived tumor in the meningeal tissues induced by adamantinomatous craniopharyngioma, which then resulted in the pathogenesis of meningioma. However, it is hard to define the time of onset. In a previous study, about 90% of the craniopharyngioma were of adamantinomatous type.[15] Therefore, the collision between craniopharyngioma and meningioma might be occasional. Finally, the coexistence of craniopharyngioma and meningioma may be crucial for the decision of neurosurgical procedures.[9,23] The surgical types and postoperative complications may present large variations. In the presence of coexistence, appropriate surgery design is helpful for the tumor resection. Perioperative treatment may contribute to the reduction of postoperative complications.

In summary, craniopharyngioma combined with meningioma is an extremely rare collision tumor. This would provide surgical significances in clinical practice. First, the collision should be considered. Meanwhile, we speculated that adamantinomatous craniopharyngioma may induce the pathogenesis of new types of meningioma, but it may be occasional.

Author contributions

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