Original article

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Endonasal endoscopic surgical treatment of craniopharyngiomas in adult patients. Our experience

Mykola O. Guk, Andriy A. Chukov

Endonasal Skull Base Neurosurgery Department, Romodanov Neurosurgery Institute, Kyiv, Ukraine

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Address for correspondence:
Andiy A. Chukov, Endonasal Skull Base Neurosurgery Department, Romodanov Neurosurgery Institute, 32 Platon Mayboroda St, Kiyv, 04050, Ukraine, e-mail: chukovandrey89@gmail.com

Objective: to estimate the results of surgical treatment of adult patients with craniopharyngiomas (CP), who underwent endoscopic endonasal surgical treatment.

Materials and methods. Treatment of 69 adult patients with CPs who underwent endonasal endoscopic surgery from 2014 to 2021 is described. Gender division: women 42% (60.9%), men 27 (39.1%). The minimum age of patients is 19 years (women 19, men 20), the maximum age is 73 years (women 73, men 66). The mean age of all patients in the group was 46.7±14.5 years, women 47.6±15.5 years, men 45.1±12.6 years. In 52 patients (75.4%) the surgical intervention was primary, and in 17 patients (24.6%) it was secondary. All patients were estimated for preoperative and postoperative endocrine and neuro-ophthalmological status in dynamics.

Results. No hemorrhagic or access-associated complications have been reported. Major complications: postoperative CSF leak - 9 patients (13%), meningitis - 10 patients (14.5%), 7 out of 8 patients with CSF leak had meningitis. 7 out of 10 patients with meningitis also had CSF leak. Other complications: acute tension pneumocephalus (2 cases, 2.9%), electrolyte disturbances (45 cases, 65.2%), severe diencephalic dysfunction (SDD) (4 cases, 5.8%). The postoperative mortality rate was 3 cases (4.35%), of which 1 due to meningitis (33.3% of all deaths), due to SDD 2 cases (66.6%). The dynamic changes of visual function were as follows: improvement in 36 patients (66.7% of all patients with preoperative visual impairment), no significant change in 7 patients (13%), deterioration in 10 patients (18.5%), 4 of which were transient. 40 patients had hypopituitarism prior to surgery, 10 of whom also had diabetes insipidus. A worsening of hypopituitarism was observed in 13 patients (32.5% of all patients with preoperative hypopituitarism) and an onset of hypopituitarism in 18 patients (26.1%). The onset of diabetes insipidus in the postoperative period occurred in 23 patients (33.3%), 7 of whom with regression.

Conclusions. Endonasal endoscopic approach is no longer an alternative for surgical treatment of certain forms of craniopharyngiomas, but it is a method of choice for most CP cases. The postoperative mortality is low. The quality of life of the operated patients is satisfactory due to a high percentage of improvement in visual function and preservation of endocrine function. The rates of CSF leak and purulent-septic complications correlate with the data of the world literature. Modern standards of treatment require the establishment of a multidisciplinary team of specialists in healthcare institutions to personalize the treatment process in patients with CPs.

Key words: *craniopharyngioma; endonasal endoscopic approach; skull base defect closure; pituitary transposition; pituitary hemitransposition; transtuberculum approach; postoperative CSF leak; hypopituitarism*

Introduction

Craniopharyngiomas (CPs) are benign epithelial congenital tumors of dysembryogenetic origin growing from the craniopharyngeal duct epithelium (Rathke's pocket) and have a slow growth rate. The occurrence of CP is rare. The incidence of detection of CPs is 0.5–3.8 cases per 1 million population per year [1, 2, 3, 4]. CPs are more common in the age groups of 5–15 and 45–60 years [4]. Despite the rapid development of the technical component of modern neurosurgical interventions, in particular endoscopic techniques and microinstrumentation, surgical removal of CPs is still a significant challenge in modern neurosurgery. High recurrence rate, localization of the tumor to the neurovascular structures of the skull base (pituitary stalk, internal carotid (ICA) and anterior cerebral arteries, optic chiasm, optic nerves, posterior communicating and ophthalmic arteries), tumor ingrowth into the diencephalic region often force the surgeon to choose between gross total and subtotal

tumor removal in view of the appearance and growth of water-electrolyte, endocrine and visual disorders in operated patients, which can lead to both a decrease in the quality of life as well as the lethal outcome. The use of endonasal endoscopic approach for the majority of CPs during the last decade is no longer considered as an alternative to surgical treatment of certain forms of CPs, but as the method of choice in most cases due to the radicality of removal, prevention of relapses and quality of life preservation of operated patients. The development of endoscopic techniques provides a surgical corridor from below, which makes it possible to perform effective dissection of the tumor from the surrounding vascular and nervous structures, as well as to avoid devascularization of the chiasm, optic nerves, and, if necessary, to perform tumor dissection from the pituitary stalk to preserve its anatomical integrity. The quality of life of operated patients is assessed taking into account the incidence of postoperative complications, endocrine outcome, and dynamics of visual disturbances. Given the historical experience of CP treatment, the use of endonasal endoscopic approach makes it possible not only to reduce the trauma and improve the cosmetic effect of surgical treatment, but also to enhance the radicality of these tumors removal, to improve the quality of life due to visual function improvement, particularly due to bony decompression of the optic nerve canals from below, as well as to achieve more effective preservation of endocrine function.

The first references to transnasal surgical interventions in CP are found in the works of E.R. Laws (1980) [6], A. König et al. (1986) [5], but they referred to the use of microsurgical technique of tumor removal, which differs significantly from the endoscopic operations used by us and described in this article. American M.H. Weiss in 1987 [7] was the first to propose the use of extended transnasal approach with additional resection of tuberculum sellae (TS) and the planum sphenoidale to widen the surgical corridor and facilitate a supradiaphragmatic approach to the tumor. The use of various modifications of transnasal microsurgical approach on different series of patients in 2000–2005 has also been widely covered [10, 11, 12, 13, 14, 19, 21, 23]. However, the limited possibilities of microsurgical technique and only direct visualization of the operating microscope did not allow safe total removal of CP, so transcranial approaches for CP removal remained relevant [19, 24]. The transition from microsurgical to endoscopic approach has been a worldwide trend for the past 30 years. The first references in the literature on endoscopic removal of CP date back to 1997 [8] and 2003 [9]. More recent papers reflect the widespread use of transnasal endoscopic approach in the treatment structure of CP. [15, 16, 17, 18, 20, 22, 25].

Objective: to estimate the results of surgical treatment of adult patients with craniopharyngiomas (CP), who underwent endoscopic endonasal surgical treatment.

Materials and methods

The study was retrospective non-selective.

The study group included 69 adult patients with CP who underwent transnasal endoscopic surgery at the department of endonasal skull base neurosurgery of the State University "Akademician A.P. Romodanov Neurosurgery Institute of the National Academy of Medical Sciences of Ukraine" in the period from 2014 to 2021.

All patients signed informed consent to participate in the study. The study was approved by the Committee on Ethics and Bioethics of A.P. Romodanov Neurosurgery Institute of the National Academy of Medical Sciences of Ukraine during the period from 2014 -2021.

The majority of the patients were women (60.9%). The minimum age of patients was 19 years, the maximum age was 73 years, and the average age was 46.7 ± 14.5 years. Among women, the minimum age was 19 years, the maximum was 73 years, and the average age was 47.6 ± 15.5 years. Among men, the minimum age was 20 years, the maximum was 66 years, and the average age was 45.1 ± 12.6 years. Surgical intervention was primary in 52 patients (75.4%) and recurrent one in 17 patients (24.6%).

Cystic CPs were diagnosed in 14 (20.3%) patients, solid - in 4 (5.8%). The absolute majority were cystic-solid tumors - 51 (73.9%) cases. Infradiaphragmatic location of the tumor was registered in 4 (5.8%) patients, supradiaphragmatic in 65 (94.2%). According to the Kassam classification, based on the ratio of the tumor to the pituitary stalk, tumors in 4 (5.8%) patients belonged to the Kassam type 0 (not classified in relation to the stalk due to infradiaphragmatic location), in 6 (8.7%) - to the preinfundibular type (Kassam I), in 40 (58%) - to the transinfundibular (Kassam II), in 19 (27.5%) - to the retroinfundibular (Kassam III), of them in 10 - with predominant extension into the third ventricle (Kassam IIIA) , in 9 – with predominant extension into the interpeduncular fossa (Kassam IIIB). Kassam type IV tumors (isolated in the third ventricle) were not considered due to their absence in our series and the inability to apply an extended endonasal endoscopic approach for their adequate surgical treatment.

Hydrocephalus was registered in 7 (10.1%) patients. 54 (78.3%) patients had visual disturbances before surgery. Of the endocrine disorders, 40 (58%) patients had hypopituitarism (hypocorticism, hypothyroidism, hypogonadism or their combination), 10 (14.5%) had diabetes insipidus.

All patients were evaluated for their preoperative and postoperative endocrine status according to hormonal studies (blood tests for adrenocorticotropic, thyroid-stimulating, luteinizing, follicle-stimulating and somatotropic hormones, cortisol, free triiodothyronine and free thyroxine, insulin-like growth factor-1), examination by endocrinologist. Visual function was assessed by a neuro-ophthalmologist's examination, which included visual acuity assessment, ocular fundus examination, and computer perimetry before and after surgical treatment.

This article contains some figures that are displayed in color online but in black and white in the print edition

Analysis of catamnesis also included assessment of visual and endocrine function in the distant postoperative period based on results of repeated examinations by endocrinologist and ophthalmologist during follow-up visits of patients.

All patients underwent preoperative magnetic resonance imaging (MRI) with intravenous contrast, 37 (53.6%) underwent native non-contrast multispiral computed tomography (MSCT) of the head, 9 (13%) underwent MSCT of the head with intravenous contrast, 13 (18.8%) underwent MSCT-angiography of the brain for differential diagnosis of a tumor (CP) with arterial aneurysms and denial of other vascular pathology. Control MRI with intravenous contrast was performed in 5 (7.3%) patients on the first day after surgery, during the first 3 days - another 5 (8.7%), during the first week - 3 (4.4%), during the first 2 months – 15 (21.7%), during the first 6 months – 39 (56.5%). During the treatment at different stages (before, during and after surgery), blood sampling was performed to analyze the acid-base composition, potassium and sodium ion concentration.

Surgical management

Surgeries were performed under multicomponent intravenous anesthesia with artificial lung ventilation. Two surgeons (1 primary, 1 assistant) and an operating nurse participated in the operation. The surgery was performed with 4 hands, in most cases the beginning of the operation (before drilling of anterior wall of the sphenoid sinus) was performed by one surgeon independently.

The initial stages are performed with a straight (0°) endoscope with a diameter of 4 mm. Both surgeons are on the right side of the patient, the surgeon manipulates the instruments in both hands, the assistant holds the camera in the right hand and simultaneously pulls the nose slightly upwards, thus widening the surgical corridor. The patient is positioned in a supine position with the head rotated 15–20° to the right. Rigid head fixation was not used, in contrast to many authors [18,22,23,25]. We put the patient's head on a horse shoe headrest, which provides a number of advantages (in particular, the ability to change the head position at different stages of intervention, which is important for extended endonasal endoscopic transtubercular approach (during additional trepanation of the tuberculum sellae (TS) and the main stage of surgical treatment, where the head flexibility significantly facilitates the procedure)). Adrenalization of the nasal passages mucosa is performed with a spongy sterile nasal pledget soaked in adrenaline and physiological solution with addition of oxymetazoline solution. Lateralization of the lower and middle nasal turbinates is performed, with minimal impact on the lower turbinates. The upper turbinates are either lateralized or resected, which greatly facilitates the anterior sphenotomy and preservation of the sphenopalatine artery. In 16 (23.2%) patients, unilateral or bilateral (2 patients, 2.9%) additional resection of the middle nasal turbinates was performed due to anatomical features (bullous type of the middle turbinate, enlargement) or narrowing of the middle and upper nasal passages, which facilitated further surgeon manipulations. All patients with primary surgical interventions (52, or 75.4%) underwent the formation of a pedicled nasoseptoperiosteal flap with the stem of the sphenopalatine artery at the base, which was turned into the nasopharynx until the end of the main stage of surgical treatment and the beginning of plastic closure of the dura mater (DM) defect.

All patients underwent resection of the bony part of the nasal septum and excision of a "window" in the rostral mucosa of the nasal septum of the opposite half of the nose for full binostral approach. Sometimes a rescue-flap was formed and used to cover the exposed cartilaginous part of the nasal septum with it, suturing it to the latter. Maximum skeletonization of anterior wall of the sphenoid sinus, resection of the crest of the sphenoid sinus was carried out. Extended anterior sphenotomy was performed using high-speed diamond and petal burrs, as well as Kerrison rongeurs. It is extremely important at this stage to preserve the integrity of the pterygopalatine artery at the base of the pedicle of nasoseptoperiosteal flap. The relief of the sphenoid sinus was leveled with a burr, additional septa and mucosa were removed. For adequate approach to the tuberculum sellae additional resection of the posterior parts of the ethmoidal labyrinth is often required. After visualizing the main anatomical landmarks of the sphenoid sinus (carotid protrusions, optic nerve canals, sella turcica, clivus of the sphenoid bone, projection of bone segments of internal carotid arteries (ICA), tuberculum sellae, platform of the sphenoid bone) trepanation of the sella turcica and tuberculum sellae is started using a diamond burr and rongeurs. In addition, straight and upwardly curved Kerrison rongeurs were used for effective detachment of the DM from the remnants of the bone plate. Small fragments of the bone plate were washed and removed with a microinstrument. In the case of suprasellar supradiaphragmatic tumor spread, trepanation is sometimes performed only at tuberculum sellae, leaving the sella turcica intact.

Pituitary transposition always requires wide trepanation of sella turcica, even though there is no tumour directly endosellarly. Classically, the bone window was formed as a trapezoid with the base facing the site of the sphenoid bone or pentagonally, allowing adequate control of the course of both optic nerves, supraclinoid branches of the ICA and the origin of ophthalmic artery, expanding the surgical corridor in subsequent stages of surgical intervention, especially during the arachnoid dissection.

For infradiaphragmatic (6 cases, 8.7%) CPs, it is enough to perform a wide sellar approach. Individualized modifications of extended endoscopic transtubercular approach were used in most (91.3%) of patients with mandatory wide opening of anterior wall of the sella turcica (actually sellar-transtubercular approach) ***(Fig. 1)***.

Doppler monitoring of the course of ICA in its infraclinoid and ophthalmic segments was performed using intraoperative transducer of 8 and 20 Hz. Bone decompression of the optic nerve canals from the side of the sphenoid sinus was additionally performed. With extended transtubercular approach, the DM was cut in the form of an inverted letter T for adequate control of the diaphragm and early identification of the pituitary stalk. Access inconveniences occurred with bleeding from the anterior intercavernous sinus, which we observed in 36 (66.7%) patients. The anterior intercavernous sinus was coagulated and incised along with the sella turcica diaphragm.

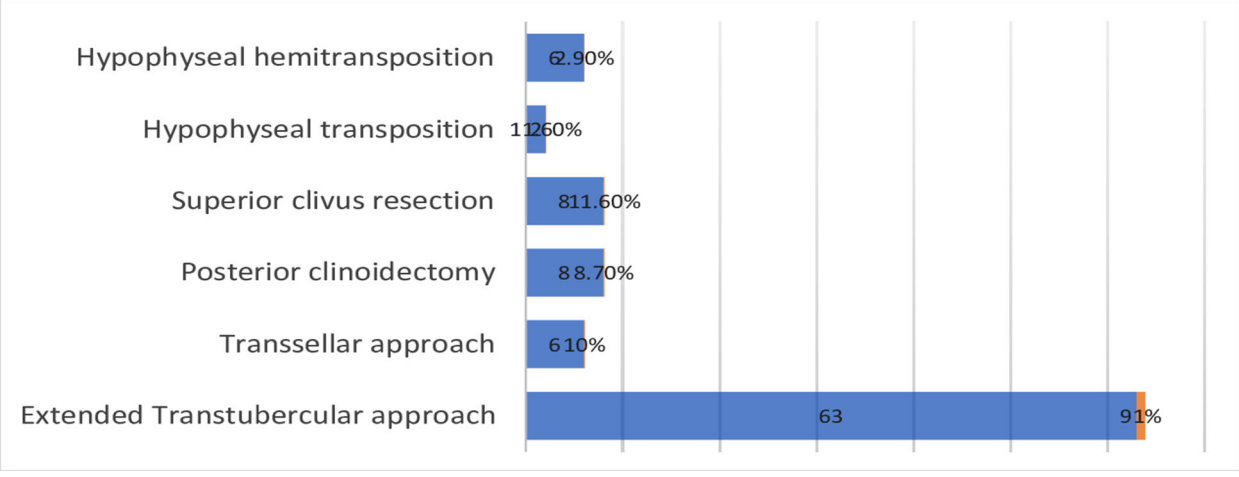


Fig. 1. Surgical techniques used during tumor removal

After visualizing the tumor and pituitary stalk in the opening of the diaphragm, arachnoid dissection was performed with maximum preservation of the perforating arteries to the chiasm and optic nerves. If possible, the capsule of the cystic part of the tumor was not cut at the first stages of dissections, but often its emptying occurred unplanned due to its accidental trauma. In our opinion, early identification of the pituitary stalk is an important technical aspect for assessing the possibility of its preservation. Tumor dissection from the surrounding brain structures was performed, avoiding arterial traumatization and with maximum control of the position of both ophthalmic, communicating and choroidal segments of the ICA, precommunicating (A1) segments of the anterior cerebral arteries, posterior communicating arteries, and in case of spread of the tumor into the interpeduncular fossa (Kassam IIIB) – basilar and posterior cerebral arteries. When the tumor spread to the third ventricle, the manipulations were performed directly in its lumen as atraumatically as possible. Manipulations on the mastoid bodies were avoided to prevent severe diencephalic dysfunction and water-electrolyte disorders.

Tumor dissection was often alternated with internal decompression to reduce the traction effect on the surrounding cerebral and vascular structures. Dissection from the pituitary stalk was not always possible, especially in Kassam II tumors. In cases of total removal, the stalk was transected. In cases where dissection from the stalk was impossible, its anatomical transection was performed in 19 (27.5%) patients. An ultrasonic aspirator was not used. All manipulations were performed with microsurgical instruments designed for endonasal interventions ("Fukushima" instrument sets, Japan, "Sugita", Japan, "Capabianca", Italy). After dissection, aspiration of the cyst contents, and internal decompression, the capsule remnants were everted and removed. For Kassam IIIB cases with tumor extension into the posterior cranial fossa (predominantly the interpeduncular fossa), access was supplemented in 8 (11.6%) cases with posterior clinoidectomy and superior clivus resection (8 cases, 11.6%), which allowed for transposition (2 cases, 2.9%), or hemitransposition (6 cases, 8.7%) of the pituitary gland. Additionally, unilateral (for pituitary hemitransposition) or bilateral transection of pituitary own ligaments in its posterolateral parts was performed, which allowed mobilizing and displacing the pituitary gland to the side to widen the surgical corridor. At the final stages of tumor removal, angled optics (30 and 45°) were used for revision of the removal cavity and additional extraction of residual tumor elements supra-antesellarly and parasellarly.

External ventricular drainage was placed in 2 patients, ventriculoperitoneal shunting was performed in 3 patients (one of the shunted patients additionally required external ventricular drainage due to isolated monoventricular hydrocephalus (isolated lateral ventricle)).

Multilayer skull base plasty was performed in all cases. For plasty, layer-by-layer placement of the patient's autogenous tissues (fat graft from the thigh or abdomen, graft of the broad fascia of the thigh) were used and artificial sealing compositions (matrix ("Tachocomb™ "/"Tachosil™"), artificial DM ("NeoDura™", Medprin Biotech, USA) "Duragen™", Integra LifeSciences Corporation, USA) in various combinations. A pedicled nasoseptoperiosteal flap was placed as an outer layer of plastic and additionally pressed with oxidized cellulose preparations and hemostatic sponge. Revision and tamponade of the nasal passages with sponge nasal tampons was performed in all patients. Intracranial pressure control using lumbar drainage before surgery was performed in all patients. The drainage was removed on the 2nd–3rd day after surgery. In the presence of tension pneumocephalus (2 cases), according to MSCT data, the drainage system was not opened, active aspiration of the cerebrospinal fluid was not performed.

Results and discussion

Preoperative MRI data revealed 6 cases of infradiaphragmatic CP (Kassam 0), 6 – preinfundibular (Kassam I), 40 – transinfundibular (Kassam II), 19 – retroinfundibular (Kassam III), 10 of them with predominant spread to the third ventricle) and 9 with predominant extension into the interpeduncular fossa.

In 3 cases there was a discrepancy of MR-image with intraoperative imaging, in 1 of them, the MRI data indicated preinfundibular tumor spread, in 2 - retroinfundibular, but during surgical dissection of the tumor from the pituitary stalk, transinfundibular pattern of growth was detected.

We consider the gradation of the radicality of CP removal by any approach to be conditional, in particular, total - removal of the cystic and solid components of the tumor with resection of all visible elements of the tumor capsule. We managed to achieve total removal of CP in 35 (50.7%) patients, which is consistent with the data of other authors [8, 9, 13, 15, 16, 17, 18, 19, 23] – 16.6–70.0%. Subtotal removal was achieved by us in 22 (32.9%) patients, which is also consistent with the data of other researchers (20.0–33.3%). Partial removal was performed in 9 (13%) patients, extended biopsy - in 1 (1.5%), cyst fenestration - in another 1 (1.5%). In 1 (1.5%) patient, the removal was not successful. The most radical was the removal of infradiaphragmatic CP (4 cases, 5.8%) and supradiaphragmatic CP (Kassam I–III), accompanied by the intersection of the pituitary stalk as a point of derivative tumor growth (19 cases, 27.5%). MRI images of the patient with gross total removal of the CP are presented in ***Fig. 2*** and ***3***. Anatomical preservation of the pituitary stalk with total tumor removal was performed in 16 (23.2%) patients, with subtotal – in 20 (29.0%). Depending on the consistency, the most total was the removal of solid CP (3 patients, 75.0%). Total removal of cystic and cystic-solid tumors was achieved in 8 (57.1%) and 23 (45.1%) patients, respectively. ***Fig. 4*** shows intraoperative photographs from an endoscope during total tumor removal. Subtotal removal was performed in 4 (28.6%) patients with cystic CP, 1 (25%) with solid and 17 (33.3%) with cystic-solid tumors. They were limited to partial removal in 1 (7.1%) patient with cystic tumor and 10 (19.6%) with cystic-solid tumors, extended biopsy - in 1 (2.0%) patient with cystic-solid CP. Only fenestration of the tumor cyst was performed in 1 patient with cystic CP ***(Fig. 5*** and ***Table 1)***.

We managed to completely avoid hemorrhagic and access associate complications. Postoperative CSF leak occurred in 8 (11.6%) patients, meningitis in 10 (14.5%). 7 out of 8 patients with CSF leak had meningitis, 7 out of 10 patients with meningitis had CSF leak. The obtained results are consistent with the data of foreign authors [8, 9, 13, 15, 16, 17, 18, 19, 23]: the incidence of CSF leak is 10.7–32.0%, meningitis is 5.0–14.2%. Other complications include acute tension pneumocephalus (2 cases, 2.9%), hypernatremia (27 cases, 39.1%), hyponatremia (18 cases, 26.1%), severe diencephalic dysfunction (4 cases, 5.8%)). Water-electrolyte disorders had varying degrees of severity and only in 4 cases resulted in severe diencephalic dysfunction. General convulsive seizures were registered in 3 patients against the background of severe water-electrolyte disorders and diencephalic dysfunction.

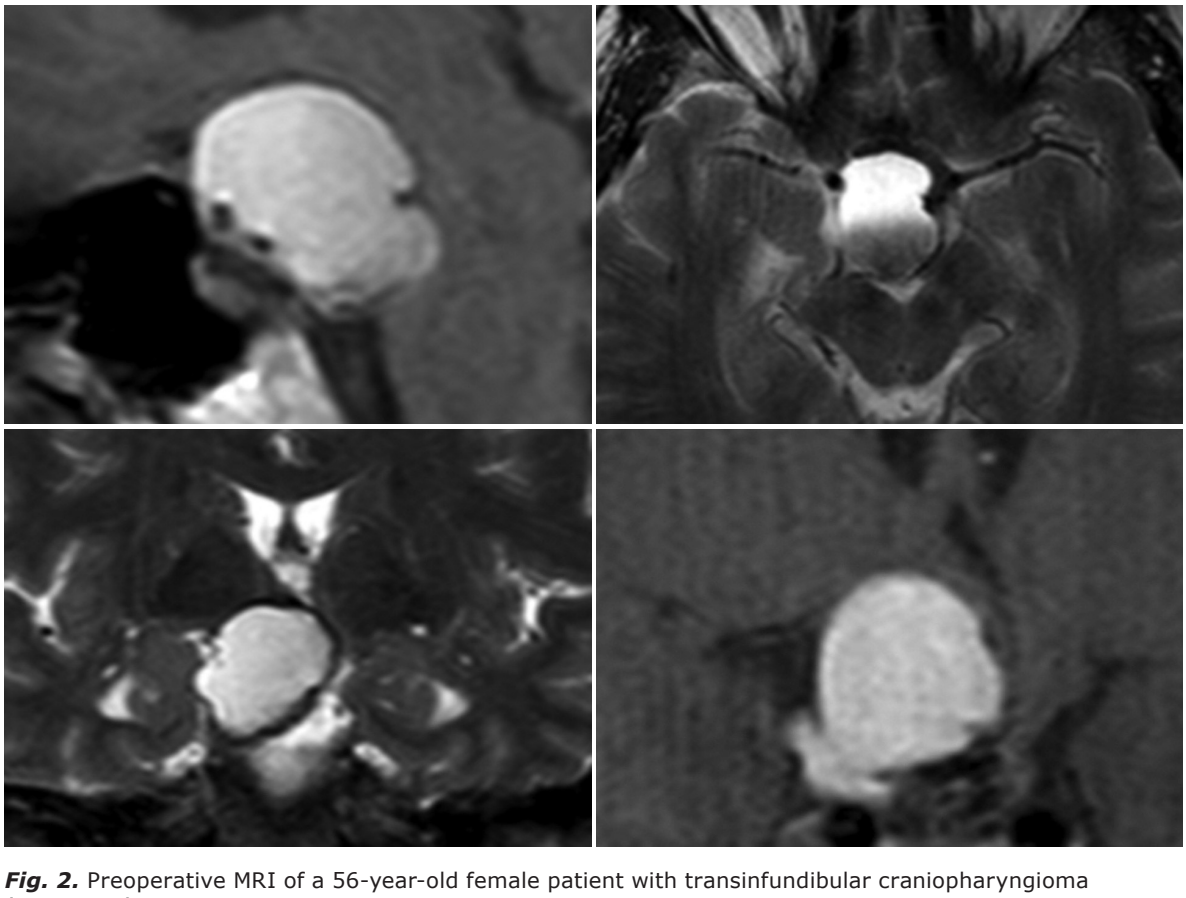


Fig. 2. Preoperative MRI of a 56-year-old female patient with transinfundibular craniopharyngioma (Kassam II)

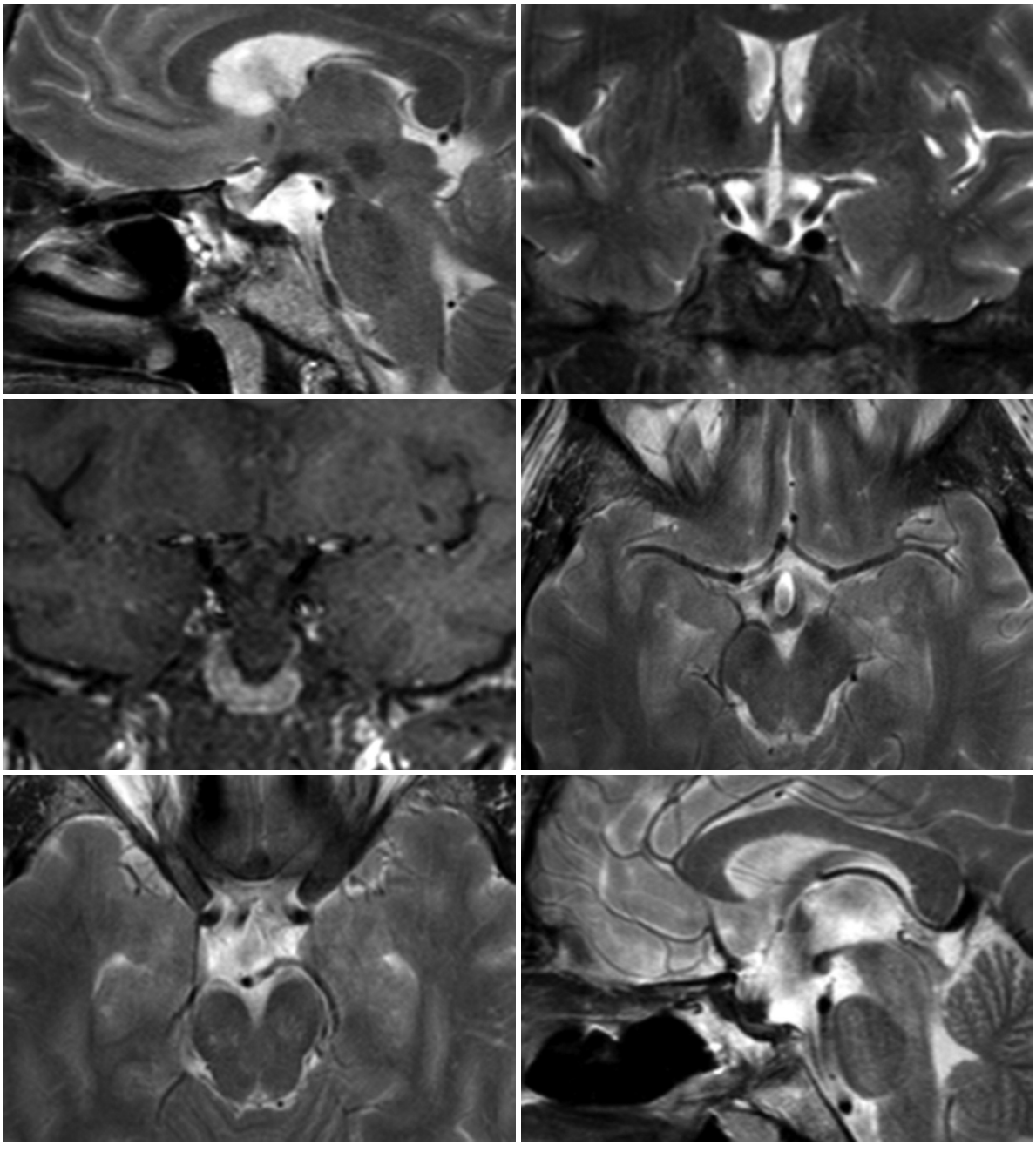
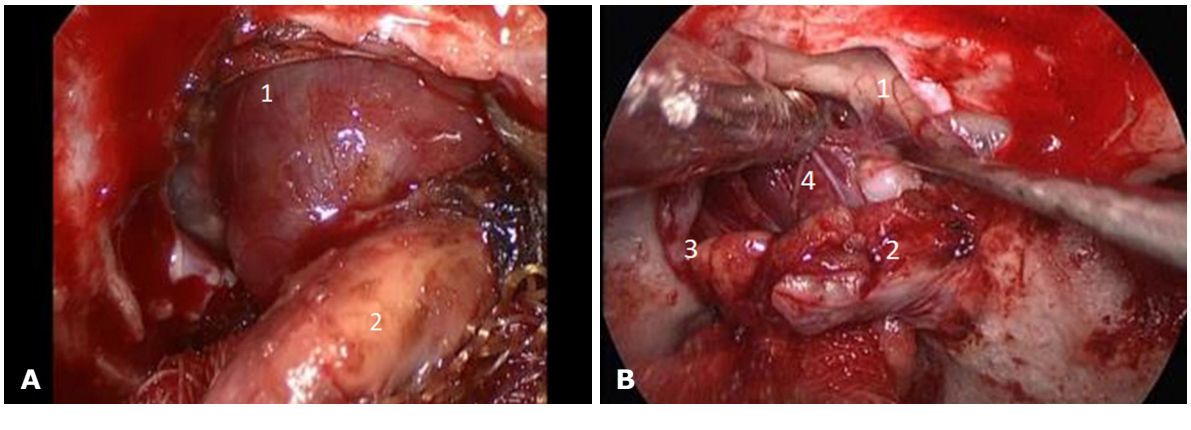


Fig. 3. Postoperative MRI of a 56-year-old female patient with a transinfundibular craniopharyngioma (Kassam II). Gross total resection



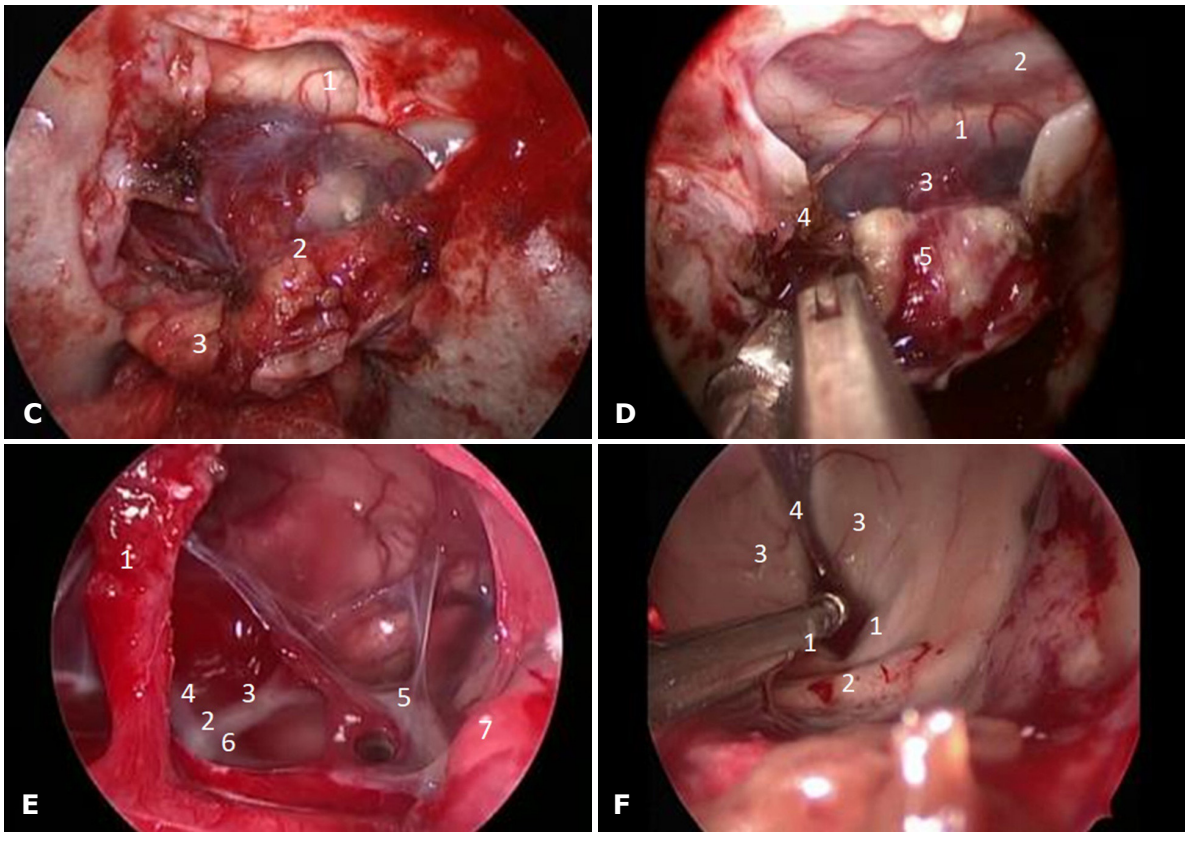


Fig. 4. Pituitary hemitransposition in Kassam II craniopharyngioma in a 56-year-old female patient: A – stages of pituitary hemitransposition (1 – tumor, 2 – pituitary gland); B - stages of pituitary hemitransposition. Arachnoid dissection of the tumor from the surrounding structures (1 –optic chiasm, 2 – pituitary displaced to the left, 3 – crossed pituitary ligaments on the right, 4 – pituitary stalk); C – complete pituitary hemitransposition (1 –optic chiasm, 2 – pituitary stalk, 3 – posterior clinoid process (right)); D – posterior intradural right-sided clinoidectomy (1 –optic chiasm, 2 – basal areas of frontal lobes, 3 – pituitary stalk (preserved), 4 – removed right posterior clinoid process, 5 – pituitary displaced to the left); E - a view of the Kassam IIIB tumor removal cavity. View of the posterior cranial fossa (1 – preserved pituitary stalk after tumor removal, 2 – bifurcation of the main artery, 3 – left posterior cerebral artery, 4 – right posterior cerebral artery, 5 – left posterior communicating artery, 6 – left superior cerebellar artery, 7 – pituitary displaced to the left); F – cavity of the third ventricle after removal of Kassam IIIA tumor (1 – mamillary bodies, 2 – posterior commissure, 3 – thalami, 4 – tela choroidea)

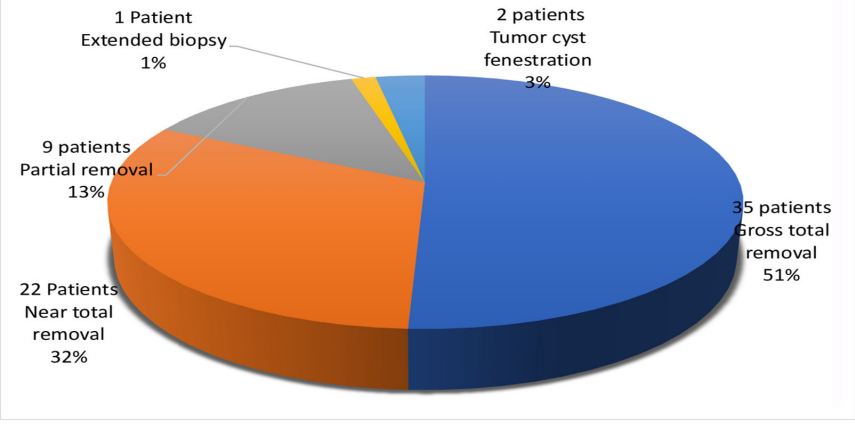


Fig. 5. Distribution of patients operated on for craniopharyngioma according to the volume of the removed tumor

Table 1. Radicality of craniopharyngiomas removal in comparison with foreign author***s***

Radicality of removal	**M. Guk, A. Chukov, n=69**	**A. Kassam et al. (2008) [23], n=16**	**E. de Divitiis et al. (2007) [27], n=10**	**A. Dehdashti et al. (2009) [28], n=6**	**L. Leng et al. (2012) [29], (n=24)**	**G. Frank et al. (2006) [16], (n=10)**	**Bin Tang et al. (2018) [26], n=92**	**L.M. Cavallo et al. (2014) [22], (n=83)**	**A.C. Stamm et al. (2011) [18], (n=18)**	**P.L. Kalinin et al. (2013) [15], (n=56)**
Gross total	35 (50,7%)	11 (68,6%)	7 (70,0%)	1 (16,6%)	16 (66,6%)	7 (70,0%)	78 (84,8%)	57 (68,7%)	12 (66,6%)	39 (69,6%)
Subtotal	22 (31,9%)	5 (31,3%)	2 (20,0%)	5 (83,3%)	8 (33,3%)	1 (10,0%)	12 (13,0%)	21 (25,3%)	5 (27,8%)	17 (30,4%)
Partial	12 (17,4%)	0	1 (10,0%)	0	0	2 (20,0%)	2 (2,2%)	5 (6,0%)	1 (5,5%)	0
Total	69	16	10	6	24	10	92	83	18	56

Postoperative mortality was 4.35% (3 cases): in 1 case due to meningitis, in 2 - due to severe diencephalic dysfunction.

Postoperative mortality was 3 cases (4.35%), of which 1 case was due to meningitis (33.3% of all deaths), 2 cases were due to severe diencephalic dysfunction (66.6%).

One patient died 9 months after surgical treatment and 6 months after radiotherapy due to progression of diencephalic dysfunction.

Cases of postoperative CSF leak was always reoperated. In cases of combined postoperative CSF and meningitis, lumbar drainage was performed for outflow, and antibiotic therapy was prescribed due to results of bacteriological culture of the cerebrospinal fluid sample and empirically considering the nosocomial flora typical of our hospital, primarily composed of gram-negative bacteria. Cerebrospinal fluid sanitation was achieved before performing a repeat surgical intervention to close the postoperative CSF leak. Repeat surgical procedures were always performed with intracranial pressure control using lumbar drainage. The method of multilayer plasty with autologous tissues of the patient and artificial sealing materials were used during the operation ("Tachocomb™ "/"Tachosil™") with the addition of sealing materials ("Bioglue™", "Covidien," "Medtronic Minimally Invas Durasil™", "CryoLife," UK, fibrin glue based on the patient's blood).

Hydrocephalus was diagnosed in 7 patients before surgery. External ventricular drainage was installed in 2 patients, and ventriculoperitoneal shunting was performed in 3 patients. One of the shunted patients additionally required external ventricular drainage due to development of isolated monoventricular hydrocephalus (isolated lateral ventricle). An Ommaya reservoir was additionally installed in the cystic component of the tumor in 1 patient.

In our opinion, the most critical indicator of the quality of life for operated patients is the preservation of visual function. Improved visual function was observed in 36 patients (66.7% of all patients with preoperative visual impairment), no significant changes were noted in 7 (13%), and deterioration of vision was observed in 10 (18.5%). However, in 4 patients, the deterioration was transient, and upon subsequent observation, visual function was restored to approximately preoperative levels. One operated patient showed a stable improvement in vision in one eye and deterioration in the other ***(Fig. 6)***. The therapy was coordinated with the neuro-ophthalmologist in our institution.

We consider endocrine function to be the second most important indicator of the quality of life of operated patients with CP. As mentioned above, 40 patients had hypopituitarism of different severity before surgery, 10 of them additionally suffered from diabetes insipidus of varying compensation degree. Deepening of hypopituitarism was registered in 13 patients (32.5% of all patients with preoperative hypopituitarism), the onset of hypopituitarism in 18 (26.1% of all patients in the series), the onset of diabetes insipidus in the postoperative period in 23 (33.3%), but in 7 patients, its regression in catamnesis was noted.

Endocrinological deterioration was registered in most cases of infradiaphragmatic (3 patients, 75% of all infradiaphragmatic CP) and radically operated supradiaphragmatic CP without anatomical preservation of the pituitary stalk (19 (27.5%)). With anatomical preservation of the stalk, endocrine function preservation was achieved (32 cases, 64.0%). Complete transposition did not result in endocrine function preservation of the pituitary gland, and with hemitransposition of the pituitary gland endocrine function preservation was achieved in 2 (33.3%) cases, which is controversial ***(Fig. 7)***.

No case of regression of diabetes insipidus that occurred before surgery was observed. Patients were examined daily by endocrinologist of the department during their hospital stay.

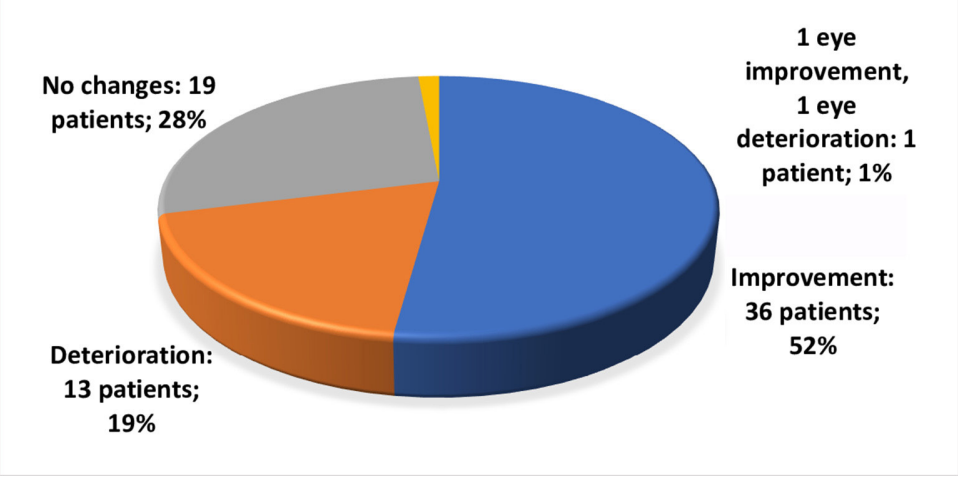


Fig. 6. Distribution of patients by severity of postoperative visual disturbances

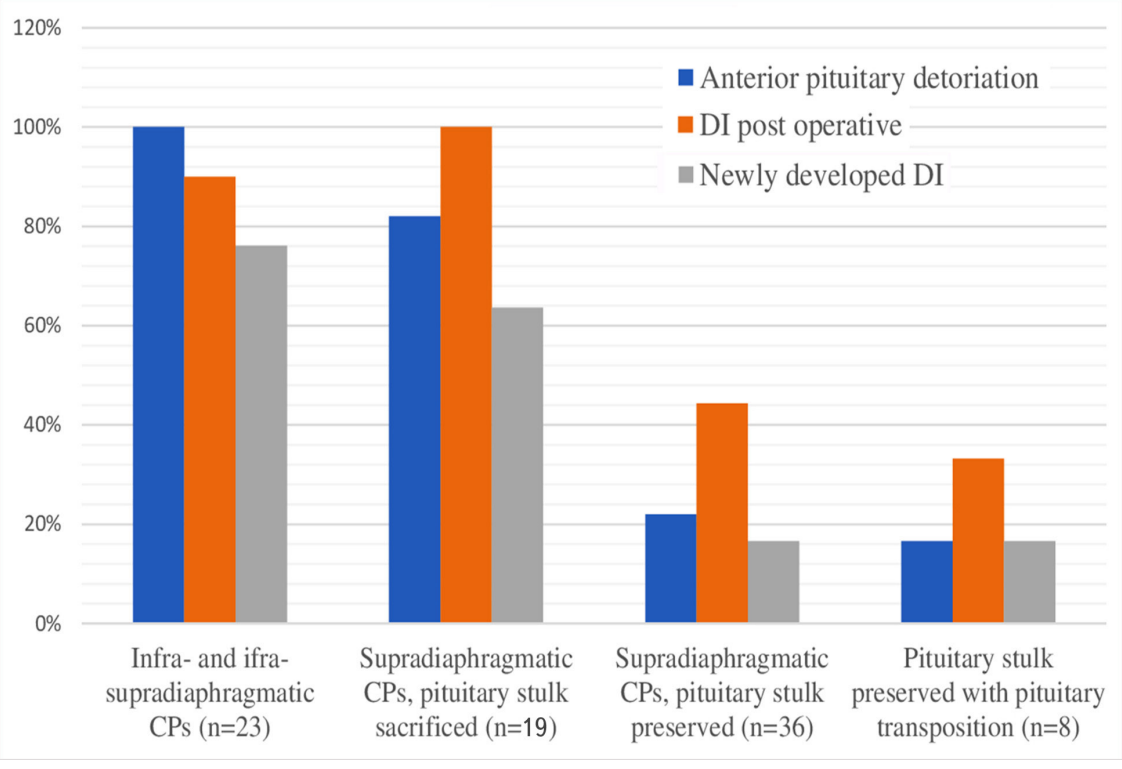


Fig. 7. Distribution of patients according to craniopharyngioma localization and severity of postoperative endocrinological disorders

Conclusions

Craniopharyngiomas represent a significant challenge in modern neurosurgery. Despite technical advances in treatment, CP surgery is associated with the risk of complications and high recurrence rates.

With the development of endoscopic neurosurgery in recent decades, endonasal approach is considered not as an alternative to surgical treatment of certain forms of CP, but as the method of choice in most cases, given the radicality of removal and improvement in the quality of life of operated patients.

The endonasal endoscopic approach, which creates an optimal surgical corridor between sella turcica diaphragm and the chiasm, was considered to be adequate for decompression of the optochiasmatic complex in all cases, as it allows early identification of the pituitary stalk and convenient arachnoid dissection.

We managed to achieve high radicality of CP removal using a transnasal endoscopic approach.

Low postoperative mortality and satisfactory indicators of the quality of life of operated patients were recorded due to the high rate of visual function improvement and preservation of endocrine function.

High rates of postoperative CSF leak and purulent-septic complications are consistent with the data of other authors, but we hope to improve these rates with the plasty technique progress.

Modern standards of treatment require the creation of a multidisciplinary team of specialists in health care institutions including a neurosurgeon, neuro-ophthalmologist, endocrinologist, and radiologist to individualize the treatment process for patients with CP.

Disclosure

Conflict of interest

The authors declare no conflict of interest.

Ethical approval

All procedures performed on patients comply with the ethical standards of institutional and national ethics committees, the 1964 Declaration of Helsinki and its amendments or similar ethical standards.

Informed consent

Informed consent was obtained from each of the patients.

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References

1. Hoffman HJ. Surgical management of craniopharyngioma. Pediatr Neurosurg. 1994;21 Suppl 1:44-9. doi: 10.1159/000120861
2. Bunin GR, Surawicz TS, Witman PA, Preston-Martin S, Davis F, Bruner JM. The descriptive epidemiology of craniopharyngioma. Neurosurg Focus. 1997 Dec 15;3(6):e1. doi: 10.3171/foc.1997.3.6.4
3. Lubuulwa J, Lei T. Pathological and Topographical Classification of Craniopharyngiomas: A Literature Review. J Neurol Surg Rep. 2016 Jul;77(3):e121-7. doi: 10.1055/s-0036-1588060
4. Müller HL, Merchant TE, Warmuth-Metz M, Martinez-Barbera JP, Puget S. Craniopharyngioma. Nat Rev Dis Primers. 2019 Nov 7;5(1):75. doi: 10.1038/s41572-019-0125-9
5. König A, Lüdecke DK, Herrmann HD. Transnasal surgery in the treatment of craniopharyngiomas. Acta Neurochir (Wien). 1986;83(1-2):1-7. doi: 10.1007/BF01420500
6. Laws ER Jr. Transsphenoidal microsurgery in the management of craniopharyngioma. J Neurosurg. 1980 May;52(5):661-6. doi: 10.3171/jns.1980.52.5.0661
7. Weiss MH. Transnasal transsphenoidal approach. In:

Apuzzo MLJ, editor. Surgery of the Third Ventricle. Baltimore: Williams & Wilkins; 1987. P. 476-94.
8. Jho HD, Carrau RL. Endoscopic endonasal transsphenoidal surgery: experience with 50 patients. J Neurosurg. 1997 Jul;87(1):44-51. doi: 10.3171/jns.1997.87.1.0044
9. Cappabianca P, Cavallo LM, Colao A, de Divitiis E. Surgical complications associated with the endoscopic endonasal transsphenoidal approach for pituitary adenomas. J Neurosurg. 2002 Aug;97(2):293-8. doi: 10.3171/jns.2002.97.2.0293
10. Chakrabarti I, Amar AP, Couldwell W, Weiss MH. Long-term neurological, visual, and endocrine outcomes following transnasal resection of craniopharyngioma. J Neurosurg. 2005 Apr;102(4):650-7. doi: 10.3171/jns.2005.102.4.0650
11. Couldwell WT, Weiss MH, Rabb C, Liu JK, Apfelbaum RI, Fukushima T. Variations on the standard transsphenoidal approach to the sellar region, with emphasis on the extended approaches and parasellar approaches: surgical experience in 105 cases. Neurosurgery. 2004 Sep;55(3):539-47; discussion 547-50. doi: 10.1227/01.neu.0000134287.19377.a2
12. Dusick JR, Esposito F, Kelly DF, Cohan P, DeSalles A, Becker DP, Martin NA. The extended direct endonasal transsphenoidal approach for nonadenomatous suprasellar tumors. J Neurosurg. 2005 May;102(5):832-41. doi: 10.3171/jns.2005.102.5.0832
13. Maira G, Anile C, Albanese A, Cabezas D, Pardi F, Vignati A. The role of transsphenoidal surgery in the treatment of craniopharyngiomas. J Neurosurg. 2004 Mar;100(3):445-51. doi: 10.3171/jns.2004.100.3.0445
14. Kouri JG, Chen MY, Watson JC, Oldfield EH. Resection of suprasellar tumors by using a modified transsphenoidal approach. Report of four cases. J Neurosurg. 2000 Jun;92(6):1028-35. doi: 10.3171/jns.2000.92.6.1028
15. Kalinin PL, Fomichev DV, Kutin MA, Kadashev BA, Astaf'eva LI, Kurnosov AB, Popugaev KA, Fomochkina LA, Tropinskaia OF. Endoscopic endonasal anterior extended transsphenoidal approach in craniopharyngioma surgery. Zh Vopr Neirokhir Im N N Burdenko. 2013;77(3):13-20; discussion 20. English, Russian
16. Frank G, Pasquini E, Doglietto F, Mazzatenta D, Sciarretta V, Farneti G, Calbucci F. The endoscopic extended transsphenoidal approach for craniopharyngiomas. Neurosurgery. 2006 Jul;59(1 Suppl 1):ONS75-83; discussion ONS75-83. doi: 10.1227/01.NEU.0000219897.98238.A3
17. Fomichev D, Kalinin P, Kutin M, Sharipov O. Extended Transsphenoidal Endoscopic Endonasal Surgery of Suprasellar Craniopharyngiomas. World Neurosurg. 2016 Oct;94:181-187. doi: 10.1016/j.wneu.2016.06.124
18. Stamm AC, Vellutini E, Balsalobre L. Craniopharyngioma. Otolaryngol Clin North Am. 2011 Aug;44(4):937-52, viii. doi: 10.1016/j.otc.2011.06.015
19. Fahlbusch R, Honegger J, Paulus W, Huk W, Buchfelder M. Surgical treatment of craniopharyngiomas: experience with 168 patients. J Neurosurg. 1999 Feb;90(2):237-50. doi: 10.3171/jns.1999.90.2.0237
20. Zoli M, Guaraldi F, Zenesini C, Acciarri N, Sollini G, Asioli S, Faustini-Fustini M, Agati R, Cirillo L, Tonon C, Lodi R, Pasquini E, Mazzatenta D. Role of endoscopic endonasal approach for craniopharyngiomas extending into the third ventricle in adults. Brain Spine. 2022 Jun 30;2:100910. doi: 10.1016/j.bas.2022.100910
21. Honegger J, Buchfelder M, Fahlbusch R, Däubler B, Dörr HG. Transsphenoidal microsurgery for craniopharyngioma. Surg Neurol. 1992 Mar;37(3):189-96. doi: 10.1016/0090-3019(92)90229-g
22. Cavallo LM, Frank G, Cappabianca P, Solari D, Mazzatenta D, Villa A, Zoli M, D'Enza AI, Esposito F, Pasquini E. The endoscopic endonasal approach for the management of craniopharyngiomas: a series of 103 patients. J Neurosurg. 2014 Jul;121(1):100-13. doi: 10.3171/2014.3.JNS131521
23. Gardner PA, Kassam AB, Snyderman CH, Carrau RL, Mintz AH, Grahovac S, Stefko S. Outcomes following endoscopic, expanded endonasal resection of suprasellar craniopharyngiomas: a case series. J Neurosurg. 2008 Jul;109(1):6-16. doi: 10.3171/JNS/2008/109/7/0006
24. Honegger J, Tatagiba M. Craniopharyngioma surgery. Pituitary. 2008;11(4):361-73. doi: 10.1007/s11102-008-0137-z
25. Almeida JP, Workewych A, Takami H, Velasquez C, Oswari S, Asha M, Bernardo A, Gentili F. Surgical Anatomy Applied to the Resection of Craniopharyngiomas: Anatomic Compartments and Surgical Classifications. World Neurosurg. 2020 Oct;142:611-625. doi: 10.1016/j.wneu.2020.05.171
26. Tang B, Xie SH, Xiao LM, Huang GL, Wang ZG, Yang L, Yang XY, Xu S, Chen YY, Ji YQ, Zeng EM, Hong T. A novel endoscopic classification for craniopharyngioma based on its origin. Sci Rep. 2018 Jul 5;8(1):10215. doi: 10.1038/s41598-018-28282-4
27. de Divitiis E, Cappabianca P, Cavallo LM, Esposito F, de Divitiis O, Messina A. Extended endoscopic transsphenoidal approach for extrasellar craniopharyngiomas. Neurosurgery. 2007 Nov;61(5 Suppl 2):219-27; discussion 228. doi: 10.1227/01.neu.0000303220.55393.73
28. Dehdashti AR, Ganna A, Witterick I, Gentili F. Expanded endoscopic endonasal approach for anterior cranial base and suprasellar lesions: indications and limitations. Neurosurgery. 2009 Apr;64(4):677-87; discussion 687-9. doi: 10.1227/01.NEU.0000339121.20101.85
29. Leng LZ, Greenfield JP, Souweidane MM, Anand VK, Schwartz TH. Endoscopic, endonasal resection of craniopharyngiomas: analysis of outcome including extent of resection, cerebrospinal fluid leak, return to preoperative productivity, and body mass index. Neurosurgery. 2012 Jan;70(1):110-23; discussion 123-4. doi: 10.1227/NEU.0b013e31822e8ffc
30. Liu F, Bao Y, Qiu BH, Mao J, Mei F, Liao XX, Huang HR, Qi ST. Incidence and Possible Predictors of Sodium Disturbance After Craniopharyngioma Resection Based on QST Classification. World Neurosurg. 2021 Aug;152:e11-e22. doi: 10.1016/j.wneu.2021.04.001