

# Anterior interhemispheric approach for removing large sellar region tumor

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## Abstract

The aim of the study was to explore anterior interhemispheric approach microsurgery for removing large sellar region tumors.

A total of 118 patients with large sellar region tumors were treated with the anterior interhemispheric approach microsurgery. There were 58 craniopharyngioma, 37 pituitary adenoma, 5 hypothalamic glioma, 7 meningioma, and 11 other tumors cases. The maximal tumor diameter ranged from 3.0 to 8.2 cm, with a mean diameter of 4.3 cm. Diabetes insipidus and fluid and electrolyte imbalance were timely controlled after surgery. Postoperative examination of endocrine and of magnetic resonance imaging (MRI) enhancement scanning of the head were performed.

Total, subtotal, and partial removal of tumors was, respectively, achieved in 80, 23, and 15 cases. A total of 109 patients had improved vision after surgery. During the hospital stay, 81 had diabetes insipidus, 68 had fluid and electrolyte imbalance, and 9 had hemorrhage and tumidness in the right frontal lobe (3 had frontal lobe contusion, and 6 had frontal lobe hematoma). The postoperative follow-up visit lasted for 3 to 105 months. During the follow-up period, 14 patients had recurrence of tumors, 38 cases had their single or multiple pituitary axis treated with hormonal replacement therapy for a long time after surgery, and 23 cases had to orally take drugs for the purpose of controlling diabetes insipidus.

The anterior interhemispheric approach microsurgery is feasible for removing large sellar region tumors without significant sequels. Active postoperative managements of diabetes insipidus and fluid and electrolyte imbalance may help patients with earlier recovery.

**Abbreviations:** CT = computed tomography, MRI = magnetic resonance imaging.

**Keywords:** brain neoplasms, microsurgery, sella turcica

## 1. Introduction

Sellar region tumors are closely related to visual pathway, hypothalamus, great vessels, and their branches of skull base. The surgery is quite difficult especially when the tumor had a large size (the maximal diameter  $\geq 3$  cm). Therefore, one of the major challenges for neurosurgery is how to achieve the maximal resection of tumors and few postoperative complications.<sup>[1–5]</sup> Different surgical approaches may be used according to different growth directions of sellar region tumors, including frontolateral approach,<sup>[6]</sup> endoscopic endonasal approach,<sup>[7]</sup> and endoscopic endonasal transsphenoidal approach.<sup>[8]</sup> Anterior interhemispheric approach can achieve resection of a variety of large tumors located along the median line of the sellar region by separating the median line structure of the frontal part exposed in the sellar region in a interhemispheric fissure manner.<sup>[9,10]</sup> As the anterior interhemispheric approach achieved good surgical effects in its application in resecting the sellar region tumors in 1990,<sup>[11]</sup> a broad and secure operation field was provided

through removing tumors by separating natural interspace. Removing tumors by viewing the median line directly can help distinguishing pituitary stalk; reduce the influences on optic nerve, internal carotid, and hypothalamus; decrease the occurrence rate of postoperative complications; and lead to earlier recovery of the patients.<sup>[9–13]</sup> This study explored surgical techniques and clinical effects of anterior interhemispheric approach microsurgery by analyzing and summarizing the clinical data of 118 patients who received the surgery for treatment from June 2006 to March 2015.

## 2. Objects and methods

### 2.1. Objects

This study was approved by the Ethic committee of PLA General Hospital. The written informed consent was obtained from each patient.

The 118 cases (62 males and 56 controls) with large sellar region tumors all had definite postoperative pathological diagnosis. They were aged 3 to 72 years and had a median age of 36.1 years, and 22 of them were <16 years. The course of disease was from 5 days to 12 years, averaging 16.7 months. Twenty-three cases had previous surgical history, and 9 of them had received prior surgeries more than twice and 5 of them had received radiosurgery treatment. Their clinical manifestations included headache (n=65), progressive vision loss (n=79), visual field defect (n=58), abnormal endocrine (n=52), preoperative epilepsy (n=4), drowsiness (n=7), and ophthalmoplegia (n=5). There were 30 cases of nonfunctional pituitary adenomas, 4 cases of prolactin secreting pituitary adenomas (3 cases had no response to 6-week of oral bromocriptine taking or were unable to tolerate drug therapy, and 1 had sharply decreased vision due to brain tumor apoplexy), 2 cases of growth hormone adenomas,

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and 1 case of thyroid-stimulating hormone adenomas among the 37 cases of large pituitary adenomas.

## 2.2. Imaging data

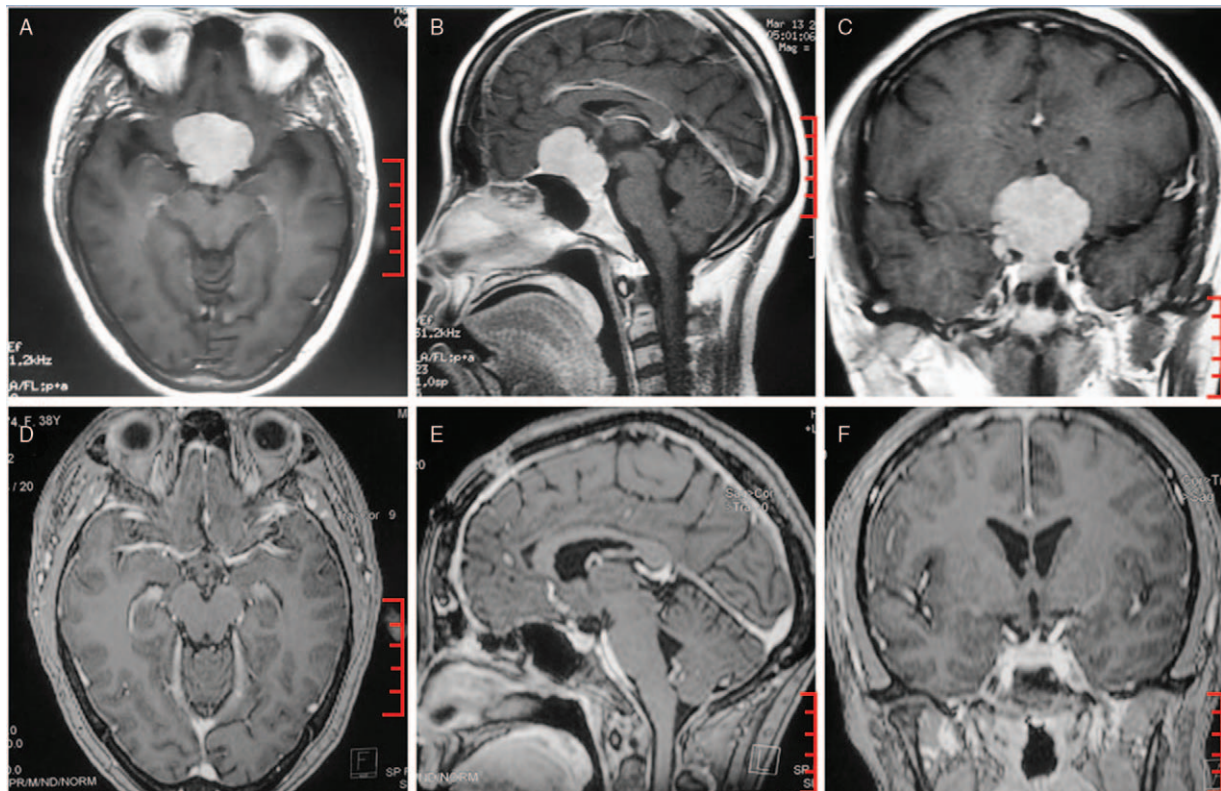
Preoperative brain MRI and computed tomography (CT) examinations were performed among the patients, and the results revealed that the maximal tumor diameter ranged 3.0 to 8.2 cm (the median tumor diameter: 4.3 cm) (Figs. 1–3) and the tumor diameter of 27 cases was >6 cm. There were 23 cases of coalescent hydrocephalus, 5 cases of infringement of cavernous sinus, 2 cases of breakthrough seller floor invasion sphenoid sinus, 37 cases of cystic solid, and 6 cases of pure cystic. The CT examination revealed 22 cases with patchy calcification in the solid portion of tumors, 7 cases with a calcification diameter >2 cm, and 8 cases with piece sample calcification of tumor capsule wall.

## 2.3. Endocrine and visual field examinations

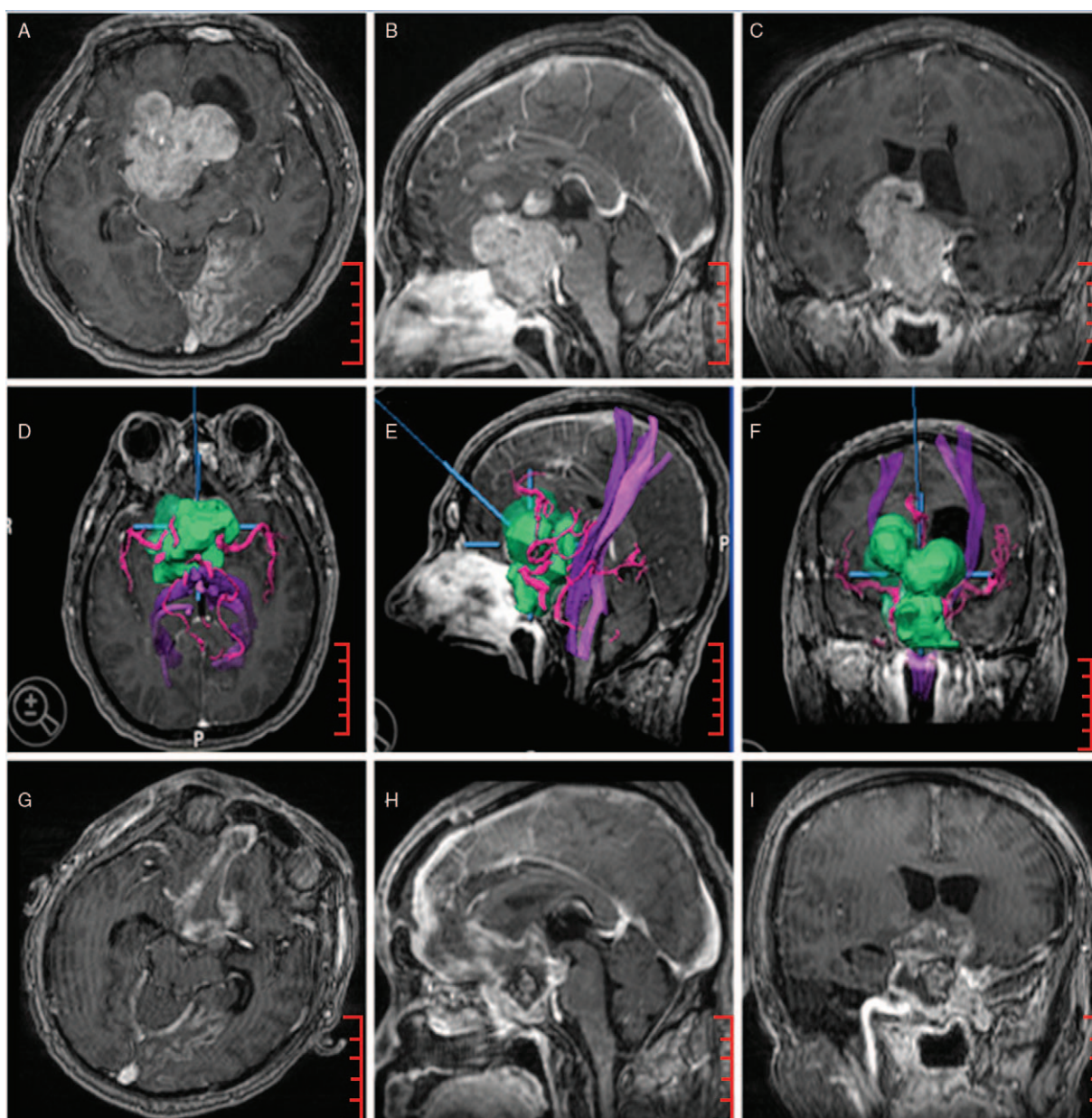
In addition to regular laboratory examinations, the patients all received endocrine examinations including examinations of serum prolactin, thyroid hormone, growth hormone, cortisol hormone, and sex hormone. Based on specific circumstances, adrenaline and thyroid hormone levels were regulated promptly. Preoperative vision and visual field examinations were performed to confirm whether the vision and visual field were impaired or not as well as the impairment degree.

## 2.4. Surgical methods

An anterior interhemispheric approach was applied in patients on the basis of preoperative imaging features and 24 cases received the tumor section surgery that is aided by nuclear magnetism. The patients were on supine position after general anesthesia with coronal incision of bilateral frontal in the hairline. The unilateral bone flap of right frontal was fashioned and the underneath was next to the basis frontalis as close as possible. During the surgery under navigation, try to keep away from the frontal sinus, reach the median line as the inner side and not keep bone edge with superior sagittal sinus (the size of the bone flap being approximately 4 cm × 5 cm). Dura mater was snipped open in an arc-shaped way, turned to the median line, and then suspended. The cerebrospinal fluid of patients with hydrocephalus was let out by puncturing paroccele frontal angle in the surgical field to lower intracranial pressure. The skull was longitudinally separated to anterior skull base along cerebral falx in front of the interhemispheric fissure and then segregated backward to the corpus callosum knee microscopically, so that the cerebrospinal fluid of interhemispheric fissure can be removed gradually and the intracranial pressure can be reduced. After the interhemispheric fissure was separated slowly and the right frontal lobe was retracted with the automatic cerebral plate, the optic nerves, optic chiasmata, anterior communicating artery complex, and tumors were adequately exposed. According to locations and characteristics, the tumors were excised piecemeal in the gaps between preoptic chiasma (first gap), postoptic chiasma, anterior communicating artery complex, and lamina terminalis without dividing anterior communicating artery. The



**Figure 1.** Preoperative MRI (A, axial view; B, sagittal view; C, coronal view) reveals sellar region meningiomas, which are resected through anterior interhemispheric approach. One month after surgery MRI reexamination shows total removal of tumors (D, axial view; E, sagittal view; F, coronal view) (A small lattice in the scale bar represented 1 cm).



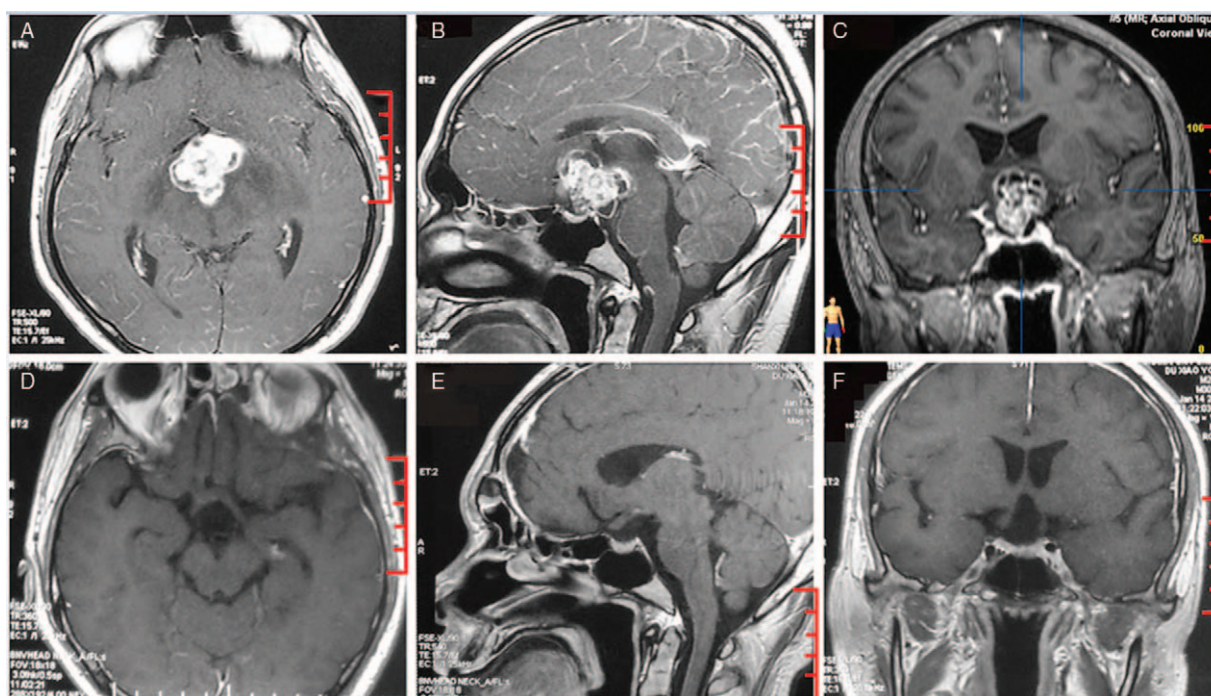
**Figure 2.** Preoperative MRI (A, axial view; B, sagittal view; C, coronal view) displays giant pituitary adenomas which are incised through anterior interhemispheric approach with the assistance of magnetic resonance navigation and navigation screenshots (D, axial view; E, sagittal view; F, coronal view) during surgery. One month after surgery MRI reexamination demonstrates total removal of tumors (G, axial view; H, sagittal view; I, coronal view) (A small lattice in the scale bar represented 1 cm).

thin-pressed lamina terminalis was incised when necessary to resect tumors in the third ventricle. After sufficient intratumorally decompression, the adhesion of tumor capsule wall with surrounding significant structures was separated microscopically.

### 2.5. Postoperative managements and follow-ups

The postoperative electrolyte levels and 24-hour input and output amount were monitored routinely. During the first 24 hours after surgery, head CT was performed for another time to get more information about intracranial conditions and endocrine hormone level was also reexamined. During the early postoperative period, cortisol hormones and thyroid hormones were given for supplement or replacement therapy, the diabetes

insipidus was controlled with pituitrin, and fluid and electrolyte imbalance was timely corrected. Endocrine hormone level was checked for another time 1 month after surgery to estimate postoperative remissions of functionality pituitary adenoma, and reexamination was performed once per 3 to 6 months after surgery. The head MRI was performed 1 to 3 months after surgery, and the head MRI was performed once every 6 months to observe tumor development if tumor residues were found, and follow-up visit and head MRI reexamination were performed once every 8 to 12 months if no tumor residues were observed. There might be postoperative residues for hypophysoma patients, and they were recommended to have the residual tumors of sphenoid sinus or sellar region resected with nasal-sphenoidal endoscopic surgery. Postoperative adjuvant therapies such as



**Figure 3.** Preoperative MRI (A, axial view; B, sagittal view; C, coronal view) indicates giant craniopharyngiomas, which are removed through anterior interhemispheric approach. Three months after surgery MRI reexamination displays total removal of tumors (D, axial view; E, sagittal view; F, coronal view) (A small lattice in the scale bar represented 1 cm).

radiotherapy or chemotherapy were adopted on the basis of different tumor pathological natures and tumor residual conditions.

### 3. Results

#### 3.1. Surgical results

The tumor excision degree was determined according to intraoperative judgments and postoperative imaging data (Figs. 1–3). There were, respectively, 80 (67.8%), 23 (19.5%), and 15 (12.7%) cases who received total, subtotal, and partial tumor removal. The clinical data of the 118 patients were detailed in Table 1. After the blood flow of bilateral anterior cerebral arteries was confirmed via ultrasound during the surgery, the anterior communicating arteries of 8 cases were disconnected, and the anterior communicating aneurysms were combined. Among the 58 craniopharyngioma cases, 35 had reserved pituitary stalk (7 were partially reserved), 9 had disconnected pituitary stalk, and 14 had no pituitary stalk. The length of hospital stay ranged between 6 and 67 days (the mean length: 16.1 days). Seven patients with functional hypophysoma underwent postoperative reexamination of internal secretions, and except for the 1 with prolactin adenoma and the 1 with growth hormone adenoma, the other 5 cases all had normal biochemical indexes. Four patients with germ-cell tumor experienced difficult preoperative diagnosis on account of hydrocephalus and optic nerve compression. The anterior interhemispheric approach was adopted and germ-cell tumor was indicated by intraoperative pathology. The germ-cell tumor was partially resected and the symptoms were relieved. The patients received further chemoradiotherapy after surgery.

#### 3.2. Postoperative complications

After surgery, 81 patients (70.4%) had diabetes insipidus, and among them, 56 (72.4%) had transient diabetes insipidus and 25 (56.4%) had persistent diabetes insipidus. Sixty-eight cases (56.4%) experienced postoperative fluid and electrolyte imbalance. Epileptic seizure occurred in 7 patients (6.4%) and the symptoms were controlled through expectant treatment. One month after surgery, improved or unchanged vision was observed in 109 cases (92.4%), deteriorated vision was shown in 9 patients (7.6%), with 2 of the 9 cases going blind. After the surgery, there were also 2 cases of cerebral infarction and 9 cases of hemorrhage and tumidness of the right frontal lobe (3 with frontal lobe contusion, and 6 with frontal lobe hematoma), and 4 of the 9 cases received evacuation of hematoma for right frontal lobe in endoscope and had good recovery after surgery, the other 5 cases received conservative treatments (1 patient discharging from hospital had grade 3 left limb myodynamia). Oculomotor paralysis occurred in 4 patients and 3 of them recovered gradually within 3 to 6 months after surgery. One patient underwent cerebrospinal fluid rhinorrhea and received neoplasty of leakage of cerebrospinal fluid in endoscope 2 weeks after surgery, and the patient's conditions were under well control after surgery. In addition, 1 patient (2.7%) died of residual tumor hemorrhage apoplexy after pituitary adenoma surgery (Table 2).

#### 3.3. Follow-up results

The median time of follow-ups was 34.5 months (range 3–105 months) and 101 patients received outpatient or telephone follow-ups. Postoperative neoplasm recurrence existed in 14 patients who were cured through reoperation (n=9), radiosur-

**Table 1****Clinical data of 118 cases with giant sellar region tumors.**

| Postoperative pathology diagnosis | Case number (case) | Average age (y) | Gender male (case) | Gender female (case) | Total resection (case) | Subtotal resection (case) | Partial resection (case) | Follow-up recurrence (case) |
|-----------------------------------|--------------------|-----------------|--------------------|----------------------|------------------------|---------------------------|--------------------------|-----------------------------|
| Craniopharyngioma                 | 58                 | 32.5            | 32                 | 26                   | 49                     | 8                         | 3                        | 7                           |
| Pituitary adenoma                 | 37                 | 47.4            | 20                 | 17                   | 22                     | 10                        | 5                        | 4                           |
| Meningeoma                        | 7                  | 43.9            | 3                  | 4                    | 5                      | 2                         | -                        | -                           |
| Hypothalamus glioma               | 5                  | 17.2            | 2                  | 3                    | —                      | 4                         | 1                        | 1                           |
| Germ-cell tumor                   | 4                  | 15.3            | 2                  | 2                    | —                      | —                         | 4                        | 2                           |
| Hypothalamus hamartoma            | 2                  | 7.5             | 1                  | 1                    | —                      | 1                         | 1                        | —                           |
| Metastatic tumor                  | 1                  | 35              | 1                  | —                    | 1                      | -                         | —                        | —                           |
| Epidermoid cyst                   | 1                  | 52              | —                  | 1                    | 1                      | —                         | —                        | —                           |
| Malignant teratoma                | 1                  | 8               | —                  | 1                    | 1                      | —                         | —                        | —                           |
| Chordoma                          | 1                  | 47              | —                  | 1                    | —                      | —                         | 1                        | 1                           |
| Optic chiasma glioma              | 1                  | 11              | 1                  | —                    | 1                      | —                         | —                        | —                           |
| Total                             | 118                | 36.1            | 62                 | 56                   | 80 (67.8%)             | 23 (19.5%)                | 15 (12.7%)               | 14                          |

gery treatment (n=4), and chemotherapy for recurrent germ-cell tumor (n=1). In the latest follow-up, 82 patients could integrate into daily work and study. Ten cases lived an independent life although their lives did not get back to normal and there were 9 patients still demanding people's care. Partial or total endocrine hormone replacement therapy was long-term applied in 38 cases, including craniopharyngiomas (n=24) and other tumors (n=14). Among those patients, 16 cases revealed newfound single- or multipituitary axis hypofunction after surgery. Moreover, 23 cases required oral drugs to control diabetes insipidus for a long time, including craniopharyngiomas (n=16) and other tumors (n=7).

#### 4. Discussion

Giant sellar region tumors (maximal diameter  $\geq 3$  cm, craniopharyngiomas, and pituitary adenomas included) have close relationship with optic nerve, hypothalamus, diacele, and basicranial aorta,<sup>[14]</sup> so the surgeries usually result in a higher operative mortality and severe postoperative complications. Moreover, there is usually a high recurrence rate after the partial excision.<sup>[15-17]</sup> Therefore, it is a great challenge how to improve

vision and endocrine symptoms and decrease postoperative complications at the same time of resecting tumors to the maximal extent.<sup>[4,15,18,19]</sup> Preoperative imageology in this group of patients had the following characteristics: giant sellar region tumors (maximal diameter  $\geq 3$  cm) grow along the median line or less than of the region of lateralization. Part of tumors has higher locations in sellar region, extending forward to skull base, pushing backward and upward ventriculus tertius or intruding into ventriculus tertius and entering backward and downward to interpeduncular fossa. Combined domestic and international experience,<sup>[17,18,20,21]</sup> we decided to resect this type of tumors through anterior interhemispheric approach with craniotomy in the right front, which could acquire satisfied effects of the total lesion removal or subtotal resection (103/118, 87.3%), visual acuity preserved or improved (92.4%) and less postoperative complications. In contrast, solid tumors in contralateral and ventriculus tertius top are difficult to be resected through conventional pterion approach adopting the lateral view angle, which has a severe impact on homolateral internal carotids and optic nerves in the surgical procedure.<sup>[22]</sup> And corpus callosum fornix approach is performed to incise corpus callosum in surgery and may result in postoperative symptoms of dysmnnesia and reticence.<sup>[17]</sup>

With the anterior interhemispheric approach, tumors are excised primarily in the gaps between preoptic chiasma (first gap), anterior communicating artery of postoptic chiasma, and lamina terminalis.<sup>[23]</sup> Twenty-two patients with giant hypophysomas were removed tumors via preoptic chiasma gap. Intrasellar tumors were scraped by curettement after sufficient decompression for optic nerves. And the size and position of remnant tumors were determined accurately via MRI scanning. Nasal sphenoid surgery can be performed to remove residual tumors in sellar region or sphenoid sinus in the lens of second phase, and radioactive surgical treatment can be used for remnant tumors of intruding into cavernous sinus. Using the approach of incise thin-pressed lamina terminalis, the tumors in the third ventricle (such as third ventricle craniopharyngioma) can be removed without dividing anterior communicating artery during surgery.<sup>[24]</sup> It is required to differentiate structures between backside of optic chiasma, median line of optic tract, and lamina terminalis while incising lamina terminalis and notice that hypothalamic supraoptic nucleus and fornixcolumn are on the lateral of hypothalamic antetheca, optic chiasma backside, and lamina terminalis.<sup>[20]</sup> Obviating electrocoagulation and traction for

**Table 2****Postoperative complications of giant hypophysoma in 118 patients.**

| Complications                      | Case number (%) |
|------------------------------------|-----------------|
| Death                              | 1 (0.8)         |
| Residual tumor hemorrhage apoplexy | 3 (2.5)         |
| Frontal lobe hematoma              | 6 (5.1)         |
| Second surgery                     | 4 (3.4)         |
| Conservative treatment             | 2 (1.7)         |
| Postoperative hypopsia             | 9 (7.6)         |
| Cerebrospinal fluid rhinorrhea     | 1 (0.8)         |
| Hypothalamus damage                | 2 (1.7)         |
| Cerebral infarction                | 4 (3.4)         |
| Intracranial infection             | 5 (4.2)         |
| Cranial nerve palsy                | 6 (5.1)         |
| Oculomotor nerve                   | 4 (3.4)         |
| Abducent nerve                     | 1 (0.8)         |
| Trochlear nerve                    | 1 (0.8)         |
| Hypopituitarism                    | 16 (13.6)       |
| Persistent diabetes insipidus      | 23 (19.5)       |

Newfound single- or multipituitary axis hypofunction in postoperation.

those structures and cautiously protecting anterior communicating artery complex as well as perforator vessels can effectively lessen postoperative complications. The lamina terminalis nexus formed by the third ventricle eminence of optic chiasma and lamina terminalis owing to tumor oppressions can be incised together with the visual removal of giant tumors which do not break through the third ventricle. Tumors always adhere with top of basilar artery and the branches, oppressing backwards cisterna interpeduncularis and growing back-downwards to prepontile cistern of dorsum sellae; in this case, the anterior interhemispheric approach can adequately expose and safely resect tumors, thus reducing damages of basilar artery, blood vessel branches, and brainstem in surgery.<sup>[15,25]</sup> Whether the lamina terminalis is removed in surgery mainly depends on the tumor location and the relationship between tumors and third ventricle.<sup>[9]</sup>

According to the location relation between tumors and optic chiasma, lamina terminalis, and anterior communicating artery complex, it is feasible to reveal tumors and incise lamina terminalis via the gaps between anterior communicating artery and optic chiasma back margin or corpus callosum, thus how to protect anterior communicating artery and branches is particularly significant. Shibuya et al<sup>[26]</sup> propose the anterior communicating artery can be ligated and interrupted to enlarge the surgical field if it is long enough. If anterior communicating artery is slender and bilateral anterior cerebral artery develops well, anterior communicating artery can be cutoff if it severely obstructs the tumor excision. But we should try not to injure perforating branch artery of anterior communicating artery, and we can distribute the blood vessels to 2 sides in the surface of resected lamina terminalis which connect with hypothalamus and optic chiasma. Do not cutoff short and thick anterior communicating artery, otherwise it may lead to unilateral ischemia of anterior cerebral artery. In addition, if the blood vessels are short, there may occur bleeding in excision; and stopping bleeding may impair the main anterior cerebral artery and cause serious consequences. In this group of patients, tumors of anterior communicating arteries in 8 cases were removed, and bilateral anterior cerebral arteries developed well with similar degree of thickness. The blood flow volume measured via color doppler was not obviously different, and relevant nerve disorders were not remained after the resection.

One or 2 bridging veins are generally severed for a favorable exposure when bridging veins going through sagittal sinus block the separation of cerebral hemispheres in anterior interhemispheric approach. Bridging veins incision results in venous return obstruction of frontal lobe, swelling and distention of brain tissues, and even hemorrhage of frontal lobe. Suzuki et al<sup>[13]</sup> adopted frontobasal interhemispheric approach to obviate bridging veins incision, which requires a low enough craniotomy, potentially generating frontal sinus infection and damaging bilateral olfactory nerves in the complex operations of ligating anterior sagittal sinus and cutting open cerebral falx. Hori et al<sup>[9]</sup> segregated narrow gaps (<2 cm) between bridging veins to resect tumors using long micro-scissor and double pole (15 cm length), thus avoiding the incision of frontal lobe. However, the surgery is extremely difficult in exposure and total removal of giant tumors. Dragging right frontal lobe for a long time can bruise brain tissues in the aged with poor flexibility of brain tissues, and especially after the blockage of venous return. As for the 4 patients (>60 years) undergoing frontal lobe hemorrhage and reoperation, their frontal lobe venous backflow is in poor conditions, and bridging veins should be incised and drained prudentially in this approach.

On the basis of clinical analysis and experience in 118 patients of giant tumors in the sellar region through the anterior interhemispheric approach, we conclude this approach has the following characteristics<sup>[9,10,23]</sup>: relatively simple craniotomy in wild vision facilitates to reveal important structures of bilateral optic nerve, optic chiasma, anterior communicating artery complex, lamina terminalis, and pituitary stalk in natural interspaces, remove main tumors in sellar region in euthyphoria, and protect hypothalamus and thalamus blood vessel branches from posterior cerebral artery in median with less interference to carotid artery; only part of patients were incised the thin-pressed lamina terminalis and there are no impairment to other brain tissues; generally have no need to resect anterior communicating artery to enlarge interspaces; at least protect unilateral olfactory nerve and avoid postoperative anosphasia. The disadvantage of this approach is narrow surgical space, thus demanding the operators to have sufficient experience and to resect the draining veins in the surface of right frontal lobe in surgery, which is unfavorable to reveal tumors with the lateral growth.<sup>[9,23]</sup>

Frequent postoperative complications of giant tumor incision in sellar region through anterior interhemispheric approach include diabetes insipidus and imbalance of water and electrolyte. In the group of cases, 81 cases (70.4%) had diabetes insipidus and 68 cases (56.4%) underwent imbalance of water and electrolyte after surgery in the hospital. Surgeries affect pituitary stalk and hypothalamus, temporarily disturb the release of antidiuretic hormone in pituitary bundle of supraoptic nucleus, and make the pituitary stalk unable to be preserved, which finally causes postoperative diabetes insipidus.<sup>[27]</sup> Postoperative abnormal alteration of blood sodium may evoke epilepsy. Consequently, for patients with diabetes insipidus, it is requisite to monitor rigorously electrolyte standard, record the intake and output volume in 24 hours, prudentially replenish salt in accordance with internal environmental circumstances, and avoid untimely overuse of mannitol.<sup>[23,27]</sup> Supplement or replacement therapies of cortisol hormones and thyroid hormones can be applied in early postoperative patients to efficiently regulate diabetes insipidus with short-effective vasopressin. For epileptics, it is necessary to redress abnormal blood sodium without delay and implement the treatment of antiepileptic drugs.

In conclusion, different kinds of giant tumors in sellar region can be excised safely and effectively through anterior interhemispheric approach, which provides a secure and broad operation vision for operators in natural interspaces, enables operators to segregate and resect tumors in microscope euthyphoria, and has little impacts on the significant structures, such as optic nerve, hypothalamus, and internal carotid. In addition, timely postoperative regulations of diabetes insipidus and imbalance of water and electrolyte should be coordinated to ensure early recovery of patients.

### Author contributions

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