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Postoperative anosmia after microsurgery for anterior circulation aneurysms

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ABSTRACT

Objective. To analyze the factors contributing to postoperative anosmia and to evaluate the effectiveness of preventive strategies in microsurgery for cerebral aneurysms.

Material and methods. The study included 117 patients with unruptured anterior circulation aneurysms who underwent surgery at the Burdenko Neurosurgery Center in 2024—2025. All patients underwent olfactometric assessment preoperatively, after 5—7 postoperative days and 6 months after surgery. Clinical, anatomical (CT angiography) and intraoperative factors were analyzed.

Results. Postoperative anosmia occurred in 55 (47%) patients with bilateral involvement in 11 (20%) cases. Anosmia developed in 70.2% of patients with anterior communicating artery (ACoA) aneurysms. Significant anatomical predictors were superior (p=0.01) and anterior (p=0.01) ACoA aneurysm dome orientation. Intraoperative risk factors included nerve compression by brain spatula (p<0.001) and arachnoid dissection of the nerve. In some cases, we noted a single-stage flow of blood along anterior cranial fossa base from olfactory tract during frontal lobe traction and arterial dissection. This «red drop» sign was an intraoperative marker of nerve injury (p=0.04). Transsylvian approach for middle cerebral artery aneurysms ensured 100% preservation of olfactory function (p<0.001). After 6 months, olfactory function recovered in 33.3% of patients. Previous COVID-19 was associated with worse recovery (p=0.05).

Conclusion. Postoperative anosmia is a frequent complication in aneurysm surgery. The main predictors are ACoA aneurysm and intraoperative traction-induced avulsion of the nerve. Preventive strategies include selection of less traumatic approach and minimized pressure on olfactory nerve. Arachnoid dissection of the nerve is not recommended.

Keywords: *postoperative anosmia, cerebral aneurysms, olfactory dysfunction, microsurgical clipping, pterional approach.*

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Abbreviations

ICA — internal carotid artery
ACA — anterior cerebral artery
AComA — anterior communicating artery
MCA — middle cerebral artery

Introduction

Surgery for anterior aneurysms of circle of Willis is a technically challenging area of cerebrovascular neurosurgery aimed at effective exclusion of aneurysm. The number of surgeries for asymptomatic unruptured intracranial aneurysms has significantly increased over the past 15 years [1]. Standard approaches (pterional, interhemispheric, transbrow) are associated with the risk of damage to olfactory nerves due to frontal lobe traction, direct compression or ischemia. This can cause postoperative anosmia (complete loss of smell) [2, 3]. Although this complication is not life-threatening, it disrupts important protective mechanisms (inability to sense gas leaks or smoke odors), changes eating behavior, causes depression, decreases libido and deteriorates the quality of life [4]. Although olfactory nerve dysfunction is a common compli-

cation with these approaches, this problem is currently underestimated. Available data are few and concern mainly patients with AComA aneurysms [5, 6]. Patient age, anatomical features of aneurysm, surgery time and mannitol were assessed as predictors of postoperative anosmia [7]. Some authors describe various methods for preventing olfactory nerve dysfunction, including mobilization of olfactory tract at the beginning of surgery and subsequent arachnoid dissection around the nerve [8], fibrin-thrombin glue to fix olfactory bulb [9] and use of aspirator instead of retractors [7, 8]. However, there are currently no uniform recommendations for preventing postoperative anosmia.

The purpose of this study was to analyze the factors leading to postoperative anosmia and its prevention in microsurgical treatment of anterior cerebral aneurysms.

Material and methods

The study included 117 patients with unruptured anterior aneurysms of circle of Willis who underwent surgery at the Burdenko Neurosurgery Center in 2024—2025. The male-to-female ratio was 32/85 (27.4/72.6%), mean age — 54±11.7 (18—76) years (median 55.1). Forty-seven (40.1%) patients had AComA aneurysms, 37 (31.6%) — MCA aneurysms, 25 (21.4%) — ICA aneurysms, 8 (6.8%) — ACA aneurysms including A1 segment in 4 (50%) cases and A2 segment in 4 (50%) cases. Inclusion criteria: unruptured anterior aneurysms of circle of Willis; age >18 years; surgery via pterional, interhemispheric or transbrow approach. Exclusion criteria: previous stroke; any preoperative olfactory impairment associated with rhinological, neurosensory or mixed lesions; endovascular treatment; comorbidities affecting olfactory function (diabetes mellitus, Parkinson's disease, dementia, etc.) and medications affecting olfactory function (antidepressants, antihistamines, etc.).

All patients underwent preoperative ENT examination and olfactometry. To determine factors influencing postoperative anosmia, we analyzed patient age and anatomical features (location, size and side) of aneurysm according to CT-AG data. We also estimated the following intraoperative parameters: microsurgical approach and its features, Sylvian fissure dissection, the number of spatulas, nature of olfactory nerve compression (direct or through a cotton swab), visual inspection of nerve integrity, fibrin-thrombin glue, arachnoid dissection around the nerve, surgery time and administration of mannitol. For AComA aneurysms, resection of rectus gyrus and dissection of interhemispheric fissure were additionally taken into account.

The majority of patients (n=112, 95.7%) underwent surgery through pterional approach for AComA, MCA, ICA and ACA aneurysms. Interhemispheric approach was used in 4 (3.5%) cases (ACA and A2 segment), transbrow approach — in 1 (0.9%) patient with AComA aneurysm. Mean aneurysm size was 6.3 mm (min 2, max 17).

ENT examination and olfactometry was performed after 5—7 postoperative days.

The follow-up assessment was performed ⩾6 months after surgery (mean 7.8 months) and included ENT examination, olfactometry and QoL survey (83 patients).

Statistical analysis was performed using R language (version 3.6.1) in RStudio environment (version 1.3.1093).

Differences of quantitative variables in independent samples were analyzed using the Mann—Whitney test. Distribution of categorical variables in independent samples was estimated using the Pearson χ^2 test and Fisher's exact test. The McNemar test was used for dependent samples. The null hypothesis was rejected at $p<0.05$.

Results

Postoperative anosmia occurred in 55 (47%) patients, while normal olfaction was observed in 62 (53%) patients. Unilateral and bilateral anosmia was observed in 44 (80%) and 11 (20%) patients, respectively. Bilateral anosmia was more common in patients with AComA aneurysms (n=7, 63.6%) and less common in aneurysms of ICA (n=3, 27.3%) and cerebral arteries (n=1, 9.1%).

Anosmia was more common in patients with AComA aneurysms (n=33, 28.2%) and less common in aneurysms of ICA (n=11, 9.4%), MCA (n=10, 8.5%) and ACA (A1 segment) (n=1, 0.9%). There was no olfactory impairment after anterior interhemispheric approach for A2 segment aneurysms.

Analysis of demographic factors revealed no significant effect of gender or age on the incidence of anosmia. Gender-adjusted distribution was comparable. Among women, anosmia was recorded in 40 (72.7%) cases, normal olfaction — in 45 (72.6%) cases. Among men, olfactory impairment occurred in 15 (27.3%) cases, intact olfactory function — in 17 (27.4%) patients. The median age in the anosmia group was 58.5 [49.1; 64.5] years, in the normal olfaction group — 54.6 [45; 65.6] years. Differences were not significant (p=0.5), but there was a trend towards older age in the anosmia group (median >55 years).

CT-AG data on AComA aneurysms are presented in **Table.**

The most significant risk factor of anosmia was direction of aneurysm dome. Significant olfactory impairment was observed in patients with anterior and superior direction. There was no significant effect of aneurysm lateralization on olfactory function in patients with AComA aneurysms (p=0.8).

When assessing the incidence of anosmia depending on microsurgical approach, we found no significant between-group differences (p=0.08). Interhemispheric approach was associated with favorable outcomes. All these patients (n=4, 100%) retained normal olfactory function. Transbrow approach was used in one case with postoperative anosmia.

Transsylvian approach without accessing the basal regions for MCA aneurysms (n=23) resulted in significantly higher olfactory preservation: postoperative anosmia was absent in all (100%) cases ($p<0.001$).

***Table*. Anatomical features of anterior communicating artery aneurysms and their impact on the development of anosmia.**

Variable	Anosmia (*n*=33, 70.2%)	Normal olfaction (*n*=14, 29.8%)	*p*-value
Size, mm [median]	6 [4.5; 8]	6 [4; 7]	0.8
Direction of dome (*n*, %)			
Anterior	10 (83.3)	2 (16.7)	0.01
Superior	17 (73.9)	6 (26.1)	0.01
Inferior	3 (75)	1 (25)	0.3
Posterior	3 (37.5)	5 (62.5)	0.4

Brain spatulas were used in 96.3% of patients with anosmia and 95.2% of patients with normal olfaction (p=1.0). The number of spatulas (one or two) had no significant effect on outcomes (p=0.7).

Unlike spatula per se, presence and nature of pressure on olfactory nerve were significant predictors of anosmia (p<0.001). Pressure with spatula was more common in the anosmia group (56.6% (n=30) versus 13.6% (n=8) in the normal olfaction group). Direct pressure (without a cotton swab) was observed in 23 (43.4%) patients with anosmia and only 3 (5.1%) ones with normal olfaction. Pressure through a cotton swab was less common and comparable in both groups (13.5% and 8.5%, respectively). Absence of pressure predominated among patients with intact olfactory function (86.4%).

Intraoperative assessment of olfactory nerve revealed significant between-group differences (p<0.001). All cases of intraoperative nerve detachment (n=18) were followed by anosmia. Among 84 patients with visually intact nerve, postoperative anosmia developed in 24% of cases (20 patients).

Frontal lobe traction and arterial dissection were followed by momentary blood flow along anterior cranial fossa base from the olfactory tract side in some cases (n=17). We designated this finding as a red drop sign **(Fig. 1)**. This symptom was associated with higher incidence of intraoperative olfactory nerve injury (57.1% of patients with this symptom vs. 22.2% of patients without red drop sign, p=0.04). Fourteen (82%) patients with red drop sign had postoperative anosmia, including 3 (18%) ones with bilateral anosmia.

Fibrin glue **(Fig. 2)** for nerve fixation before subfrontal approach (n=12) was somewhat more common among patients with normal olfactory function (9 patients versus 3 patients in the anosmia group). However, differences were not significant (p=0.1).

Arachnoid dissection around olfactory nerve **(Fig. 3)** for its better mobilization was followed by anosmia in all patients (n=4).

Mannitol was more common among patients with normal olfaction (79% versus 63%). However, its effect on olfactory preservation was not significant (p=0.1).

Surgery time, access side, dissection of interhemispheric fissure from the skull base, Sylvian fissure dissection and rectus gyrus resection had no significant effect on postoperative olfactory impairment (p>0.05).

A follow-up examination of 83 patients after 6 months revealed that 11 (33.3%) out of 33 patients with anosmia had olfactory recovery after surgery. Regarding bilateral anosmia, olfactory function recovered in 3 out of 11 patients (27.3%) on contralateral side. Among patients with anosmia and no previous COVID-19 (n=10), olfactory function recovered in 6 (60%) ones compared to 5 (21.7%) patients with previous COVID-19 (n=23) (p=0.05).

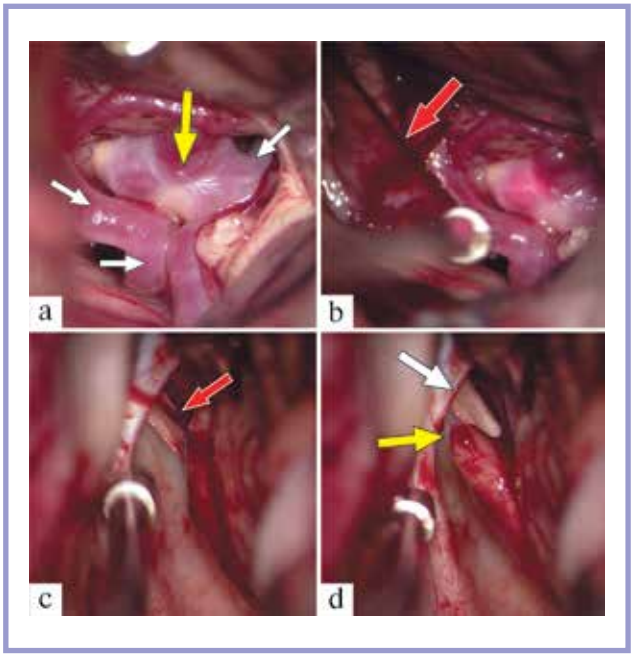


***Fig. 1*. Red drop sign in microsurgery for AComA aneurysm. Left-sided supraorbital craniotomy.**
a — aneurysm (yellow arrow). Segment A1 and segment A2 of anterior cerebral artery (white arrows); b — dark (venous) blood clot on basal surface of the frontal lobe (red arrow), captured by the tip of the aspirator; c — blood clot near detached olfactory bulb on the left (red arrow); d — olfactory nerve stump on the left (yellow arrow) and intact olfactory nerve on the right (white arrow).

Discussion

Prevention of anosmia in surgery for anterior aneurysms is of high social and medical significance, especially in context of widespread interventions for unruptured aneurysms.

According to our data, olfactory impairment developed in 47% of patients after surgery for unruptured anterior aneurysms. In most cases (67%), anosmia was unilateral. This complication was more common in AComA aneu-

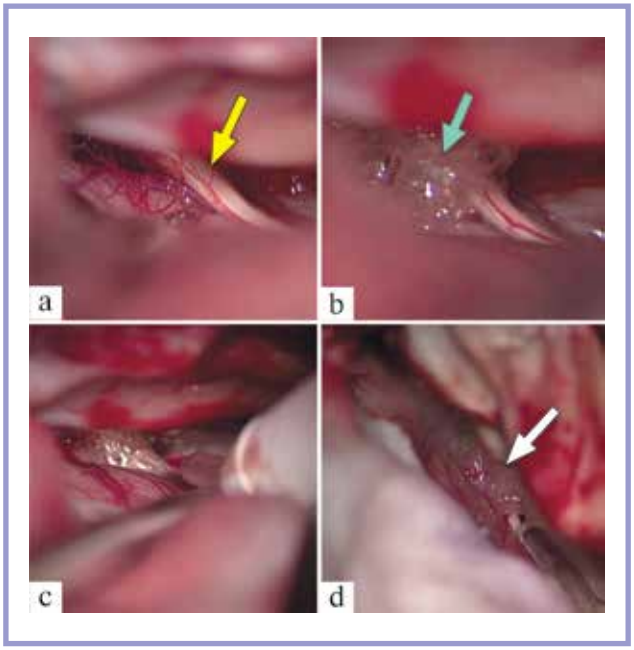


Fig. 2. **Olfactory nerve fixation using fibrin-thrombin glue.**
a — subfrontal approach to olfactory nerve (yellow arrow) near ethmoid bone on the right; b — olfactory nerve protection using a fragment of hemostatic gauze (green arrow); c — spraying of fibrin-thrombin glue components onto olfactory nerve on the right; d — adhesive film (white arrow) on the fixed olfactory nerve on the right.

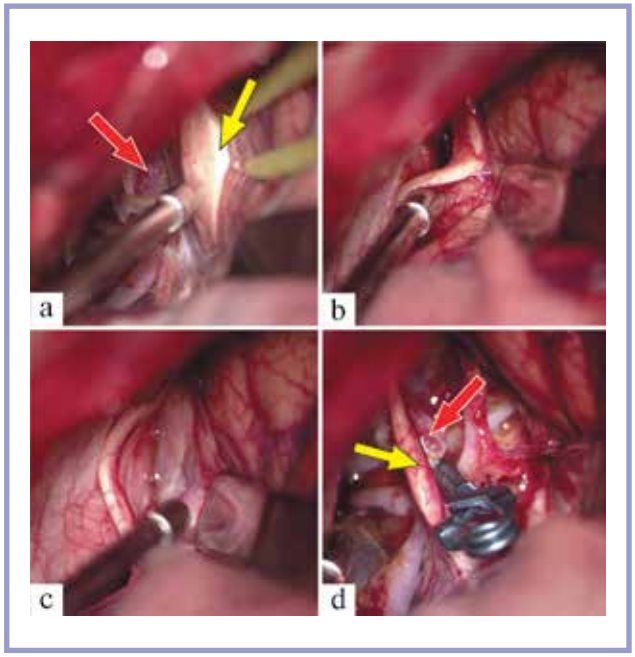


Fig. 3. **Dissection of olfactory nerve from basal surface of the frontal lobe.**
a — subfrontal approach to anterior communicating artery; aneurysm — red arrow, left olfactory nerve in arachnoid sheath on basal surface of the left frontal lobe — yellow arrow; b — initial stages of olfactory nerve dissection; c — completely mobilized olfactory nerve; d — aneurysm clipping (red arrow) after mobilization of olfactory nerve (yellow arrow).

rysms (70.2%). This fact is explained by anatomical proximity of olfactory tracts to this area. These data are consistent with results of other studies. Thus, Aydin I.H. et al. [7] reported postoperative anosmia in 58% of cases.

When analyzing anatomical predictors of anosmia, we found no significant effect of aneurysm size on postoperative outcomes ($p>0.05$). This is also confirmed by literature data [8].

The most significant predictor was direction of ACoмA aneurysm dome. There was significantly higher incidence of olfactory impairment for anterior (83.3%; $p=0.01$) and superior (73.9%; $p=0.01$) directions. Superior orientation requires deeper dissection of interhemispheric fissure from the base and greater traction of the frontal lobe. Anterior direction is associated with proximity to basal regions of the frontal lobe and olfactory bulb [10].

Analysis of surgical approaches demonstrated 100% preservation of olfactory function for interhemispheric approach to A2 segment aneurysms ($n=4$). This is consistent with the authors' opinion on more accurate nature of this approach with respect to olfactory nerves when properly selected for indications [6]. Transsylvian approach instead of subfrontal one for MCA aneurysms preserved olfactory function in all 23 cases ($p<0.001$). This demonstrates the advantages of this approach minimizing traction of frontal lobe and, consequently, olfactory structures. We found no discussion of this issue in the literature.

Olfactory nerve compression by spatula, especially direct application (without a cotton swab), was a significant predictor of anosmia ($p<0.001$). Therefore, we recommend avoiding excessive and prolonged pressure to maintain microcirculation in olfactory tract. For this purpose, protective pads (cotton swabs) can be used, and frontal lobe traction can be minimized. This is consistent with recommendations of several neurosurgical schools [7, 8]. Andrade-Barazarte H. et al. [8] recommended replacing long-term retractors with aspirator and bipolar forceps. Aydin I.H. et al. [7] suggested replacing retractor with aspirator to prevent postoperative olfactory impairment.

A natural consequence of trauma was condition of olfactory nerve. Intraoperative damage was observed exclusively among patients with anosmia. Red drop sign was associated with high incidence of nerve injury (57.1%; $p=0.04$). This symptom is caused by rupture of small veins accompanying olfactory filaments at the site of their entry into the perforated plate of the ethmoid bone during frontal lobe traction. Impaired microcirculation of the nerve following damage to perineural venous network explains high risk of anosmia. This allows us to consider this symptom as an intraoperative marker requiring the surgeon to exercise particular caution to limit traction and damage to the second olfactory nerve.

According to our data, intraoperative administration of mannitol and surgery time does not influence anosmia. Aydin I.H. et al. [7] obtained similar data.

Fibrin glue was somewhat more common among patients with preserved olfactory function (14.5% versus 5.6% in the anosmia group). However, differences were not significant ($p=0.1$). This was likely due to small sample of pa-

tients who received fibrin-thrombin glue. Literature data demonstrate good results for this prophylactic method. Cho H. et al. [9] reported postoperative anosmia in 2.8% of patients in the olfactory nerve «protection» group versus 25% in the «no protection» group.

Some authors describe arachnoid dissection around olfactory nerve as a method for preventing postoperative anosmia [8]. According to our data, this procedure resulted in anosmia in all cases. This is a quite labor-intensive and traumatic procedure with inevitable damage to some small arteries and veins blood supplying to the nerve. Nerve dissection prolongs surgery by at least 20–30 min. Under continuous cerebrospinal fluid aspiration, this promotes brain relaxation and gravitational frontal lobe retraction from anterior cranial fossa base. All of this increases the risk of olfactory nerve avulsion near ethmoid bone. We attempted this technique in four patients and finally do not recommend arachnoid dissection as a method for preventing olfactory impairment.

A follow-up examination six months after surgery revealed olfactory recovery in 33.3% of patients with early postoperative anosmia. None patient had nerve avulsion. This indicates reversibility of surgically induced anosmia without anatomical nerve damage. These results are consistent with literature data on partial or complete olfactory recovery in delayed postoperative period [10].

Postoperative olfactory recovery was significantly more common among patients without previous COVID-19 (p=0.05). COVID-19 is known to cause persistent damage to olfactory epithelium and neuroepithelial structures due to viral penetration through ACE2 receptors expressed in supporting cells of olfactory epithelium [11]. Previous infection decreases regenerative potential of olfactory neuroepithelial lining and leads to subclinical deficit with subsequent aggravation after additional intraoperative damage [12].

Conclusion

Postoperative anosmia is a common complication in surgery for anterior brain aneurysm. The main predictors are AComA aneurysms and intraoperative nerve avulsion. Preventive methods include accurate approach and minimized pressure on olfactory nerve. Arachnoid dissection around the nerve is not recommended.

Author contribution:
Concept and design of the study — Pilipenko Yu.V., Margulis M.E., Konovalov A.N.
Collection and analysis of data — Margulis M.E., Kholmatov M.B.
Statistical analysis — Strunina Yu.V.
Writing the text — Margulis M.E.
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No conflict of interests to declare.

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COMMENT

This study is relevant for neurosurgeons. The authors presented a large sample of patients, identified the incidence of anosmia and analyzed its predictors depending on intraoperative microsurgical techniques. Final conclusions and recommendations will be useful for neurosurgeons.

Interestingly, one of the authors' conclusions contradicts the generally accepted concept expressed by most other authors. This concerns arachnoid dissection of olfactory nerves due to worse prognosis for anosmia. Most authors, on the contrary, recommend arachnoid dissection to reduce olfactory nerve tension during frontal lobe traction. However, the authors obtained poor results after arachnoid dissection of olfactory nerves. I cannot rule out that this result is not a global trend, but merely reflects a particular situation encountered in this sample. Therefore, conclusion regarding undesirable dissection is the authors' opinion.

This report will be interesting for neurosurgeons and neurologists thanks to a thorough analysis of predictors of anosmia and clear recommendations for preventing this complication.

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