Anosmia after anterior communicating artery aneurysm surgery

see also Anosmia after anterior communicating artery aneurysm endovascular treatment.

Pathogenesis

For Bor et al. anosmia occurs after coiling in 1 of every 6 subarachnoid hemorrhage patients, but has a good prognosis in most patients. The cause of anosmia after coiling for ruptured aneurysms remains elusive; severity of the initial hemorrhage or long lasting hydrocephalus may be contributing factors [1)].

In patients with subarachnoid hemorrhage (SAH), anosmia has mainly been reported after surgery for anterior communicating artery aneurysms. Olfactory dysfunction after SAH caused by rupture of the ACoA are very frequent and were present in both treatment groups (aneurysmal clip placement and coil embolization).

Cerebral vasospasm and frontal lobe lesions are related to worse performance on an olfactory testing in patients undergoing endovascular coil embolization [2)].

Both clip treatment and SAH contribute to the occurrence of anosmia, with different chances of improvement. Olfactory dysfunction occurs in almost all patients on the side of surgery and can occur subclinically after coil deployment [3)].

Its occurrence after coiling suggests not only damage to the olfactory nerve by clipping but also that the SAH itself plays a role in its pathogenesis [4)].

The highest incidence of olfactory dysfunction following a pterional approach and its modifications for an intracranial aneurysm has been reported in cases of anterior communicating artery (ACoA) aneurysms. The radiological characteristics of unruptured ACoA aneurysms affecting the extent of retraction of the frontal lobe and olfactory nerve were investigated as risk factors for postoperative olfactory dysfunction. In cases of unruptured ACoA aneurysm surgery, the height of the aneurysm neck and the estimated extent of brain retraction were both found to be powerful predictors of the occurrence of postoperative olfactory dysfunction. [5)].

Wongsuriyanan and Sriamornrattanakul published that the interhemispheric approach provided an excellent surgical corridor for clipping anterior communicating artery aneurysms (AcoAAs). However, an important disadvantage of the approach is obtaining proximal control at A1 in the last stage of dissection, especially in anterior or superior projecting AcoAAs and ruptured cases.

Postoperative anosmia was detected in 22.7% [6)].

For Ito et al. the causes of postoperative anosmia in subfrontal and interhemispheric approach were as follows: sectioning of olfactory tracts intentionally or not, avulsion of olfactory bulbs and probability of ischemic or minor mechanical insults to olfactory tracts. However, these matters rarely occur in posterior interhemispheric approach because of little exposure of olfactory nerves. The mechanisms of postoperative anosmia in posterior interhemispheric approach were considered to be as follows: sinking of frontal lobes due to excessive drainage of cerebrospinal fluid and over-retraction of frontal lobes. The incidence of postoperative anosmia decreased from 27.0% via subfrontal and interhemispheric approach to 5.5% via posterior interhemispheric approach [7].

Prevention

Superior direction of aneurysm appears associated with postoperative olfactory dysfunction. Olfactory protection using gelfoam and fibrin glue could be a simple, safe, and useful method to preserve olfactory function during A-com aneurysm surgery. [8].

For Aydin et al. the functions of olfactory nerve could be preserved at a relatively high rate of 85 per cent. This high rate resulted from the microtechnique employed as well as the relatively cautious frontal lobe retraction which was less than 1.5 cm [9].

For Fujiwara et al. Unilateral dural incision and unilateral brain retraction without elevation of the frontal lobe from the frontal base are important, because frontal lobe depression and elevation during surgery may injure the olfactory nerve [10].

Outcome

For Bor et al. anosmia occurs after coiling in 1 of every 6 SAH patients, but has a good prognosis in most patients [11].

Olfactory dysfunction has an important impact on quality of life. Recovery after traumatic anosmia has been recorded up to 5 years after injury. Nevertheless, Eriksem et al. believe that the damage is permanent when lasting 35 months or longer [12].

Case series

The interhemispheric approach (IHA) provides an excellent surgical corridor for clipping anterior communicating artery aneurysms (AcoAAs). However, an important disadvantage of the approach is obtaining proximal control at A1 in the last stage of dissection, especially in anterior or superior

projecting AcoAAs and ruptured cases. Wongsuriyanan and Sriamornrattanakul described and evaluated the microsurgical clipping of AcoAAs using the IHA with early A1 exposure.

This was a retrospective descriptive study in patients with AcoAA who received microsurgical clipping through the IHA with early A1 exposure between April 2016 and May 2019. Aneurysm morphology, projection, completeness of clipping, surgical complications, and outcomes were collected from medical records.

Twenty-five patients with AcoAA received microsurgical clipping via the IHA with early A1 exposure. Twenty-three patients (92%) presented with subarachnoid hemorrhage. Intraoperative rupture while dissecting the interhemispheric fissure occurred in 2 cases, for which proximal control via subfrontal route was effectively performed. Of the patients, 100% achieved complete obliteration of their aneurysms. Postoperative anosmia was detected in 22.7%. In ruptured cases, 16 (88.9%) of the good grade patients achieved a good outcome (Glasgow Outcome Scale scores of 4 and 5) at 3 months after the operation.

The IHA with early A1 is safe and effective for clipping AcoAAs. [13)].

Hendrix et al. assessed the risk for olfactory dysfunction following surgical treatment of unruptured cerebral aneurysm via the supraorbital minicraniotomy. A retrospective review of patients with electively treated cerebral aneurysms who underwent perioperative assessment of olfactory function using a sniffin' sticks odor identification test between January 2015 and January 2016 was performed. A subgroup of patients without history of subarachnoid hemorrhage, without prior intracranial aneurysm treatment, and confirmed olfactory function underwent supraorbital keyhole craniotomy for aneurysm clipping. Microscopic and endoscopic videos were reviewed for this subgroup. Sixty-four patients who underwent elective aneurysm treatment either via surgical clipping or endovascular aneurysm occlusion were identified. Prior to treatment, 4/64 (6.3%) demonstrated bilateral anosmia. Collectively, 14 patients (21.9%) met subgroup criteria of supraorbital keyhole craniotomy for aneurysm clipping. Here, olfactory performance significantly decreased postoperatively on the side of craniotomy (ipsilateral, P = 0.007), whereas contralateral and bilateral olfactory function remained unaltered (P = 0.301 and P = 0.582, respectively). Consequently, 4/14 patients (28.6%) demonstrated ipsilateral anosmia 3 months after surgery. One patient (1/14, 7.1%) also experienced contralateral anosmia resulting in bilateral anosmia. Intraoperative visualization of the olfactory tract and surgical maneuvers do not facilitate prediction of olfactory outcome. The supraorbital keyhole craniotomy harbors a specific risk for unilateral olfactory deterioration. Lack of perioperative olfactory assessment likely results in underestimation of the risk for olfactory decline. Despite uneventful surgery, prediction of postoperative olfactory function and dysfunction remain challenging [14)].

A total of 63 patients (aged 41-79 yr, mean 64 yr) with relatively small AcomA aneurysms clipped via the lateral supraorbital approach were retrospectively analyzed among the 105 AcomA aneurysms treated by clipping from 2005 to 2014. Neurological and cognitive functions were examined by several scales, including the modified Rankin Scale (mRS) and Mini-Mental Status Examination. The depressive state was assessed using the Beck Depression Inventory and Hamilton Depression Scale. The state of clipping was assessed 1 yr and then every few years after the operation by 3-dimensional computed tomography angiography.

Complete aneurysm neck clipping was confirmed in 62 aneurysms (98.4%). Perioperative complications occurred in 5 patients (5/63; mild frontalis muscle weakness in 3, anosmia in 1, and

meningitis in 1). The mean clinical follow-up period was 5.2 ± 2.1 yr. No patient showed an mRS score more than 2 and all were completely independent in daily life. The depression scores were significantly improved after surgery. The overall mortality was 0% and overall morbidity (mRS score > 2 or Mini-Mental Status Examination score < 24) was 1.6%. All completely clipped aneurysms did not show any recurrence during the mean follow-up period of 4.9 ± 2.1 yr.

Keyhole Lateral supraorbital approach to clip relatively small unruptured AcomA aneurysm promises less invasive and durable treatment [15].

Cho et al. retrospectively reviewed the medical records of patients who underwent surgical clipping for unruptured aneurysm from 2011-2013 by the same senior attending physician. Since March 2012, olfactory protection using gelfoam and fibrin glue was applied in A-com aneurysm surgery. Therefore we categorized patients in two groups from this time-protected group and unprotected group.

Of the 63 enrolled patients, 16 patients showed postoperative olfactory dysfunction-including 8 anosmia patients (protected group : unprotected group=1 : 7) and 8 hyposmia patients (protected group : unprotected group=2 : 6). Thirty five patients who received olfactory protection during surgery showed a lower rate of anosmia (p=0.037, OR 10.516, 95% CI 1.159-95.449) and olfactory dysfunction (p=0.003, OR 8.693, 95% CI 2.138-35.356). Superior direction of the aneurysm was also associated with a risk of olfactory dysfunction (p=0.015, OR 5.535, 95% CI 1.390-22.039).

Superior direction of aneurysm appears associated with postoperative olfactory dysfunction. Olfactory protection using gelfoam and fibrin glue could be a simple, safe, and useful method to preserve olfactory function during A-com aneurysm surgery. [16].

The highest incidence of olfactory dysfunction following a pterional approach and its modifications for an intracranial aneurysm has been reported in cases of anterior communicating artery (ACoA) aneurysms. The radiological characteristics of unruptured ACoA aneurysms affecting the extent of retraction of the frontal lobe and olfactory nerve were investigated as risk factors for postoperative olfactory dysfunction.

Methods: A total of 102 patients who underwent a pterional or superciliary keyhole approach to clip an unruptured ACoA aneurysm from 2006 to 2013 were included in this study. Those patients who complained of permanent olfactory dysfunction after their aneurysm surgery, during a postoperative office visit or a telephone interview, were invited to undergo an olfactory test, the Korean version of the Sniffin' Sticks test. In addition, the angiographic characteristics of ACoA aneurysms, including the maximum diameter, the projecting direction of the aneurysm, and the height of the neck of the aneurysm, were all recorded based on digital subtraction angiography and sagittal brain images reconstructed using CT angiography. Furthermore, the extent of the brain retraction was estimated based on the height of the ACoA aneurysm neck.

Results: Eleven patients (10.8%) exhibited objective olfactory dysfunction in the Sniffin' Sticks test, among whom 9 were anosmic and 2 were hyposmic. Univariate and multivariate analyses revealed that the direction of the ACoA aneurysm, ACoA aneurysm neck height, and estimated extent of brain retraction were statistically significant risk factors for postoperative olfactory dysfunction. Based on a receiver operating characteristic (ROC) analysis, an ACoA aneurysm neck height > 9 mm and estimated brain retraction > 12 mm were chosen as the optimal cutoff values for differentiating

anosmic/hyposmic from normosmic patients. The values for the area under the ROC curves were 0.939 and 0.961, respectively.

Conclusions: In cases of unruptured ACoA aneurysm surgery, the height of the aneurysm neck and the estimated extent of brain retraction were both found to be powerful predictors of the occurrence of postoperative olfactory dysfunction. [17].

Matano et al. presented a fibrin-gelatin fixation method that provides reinforcement and moisture to help preserve the olfactory nerve when using the anterior interhemispheric approach and describe the results and outcomes of this technique. We analyze the outcomes with this technique in 45 patients who undergo surgery for aneurysms, brain tumors, or other pathologies via the anterior interhemispheric approach. Anosmia occurred in 4 patients (8.8%); it was transient in 2 (4.4%) and permanent in the remaining 2 (4.4%). Brain tumors clearly attached to the olfactory nerve were resected in the patients with permanent anosmia. We found a significant difference in the presence of anosmia between patients with or without lesions that were attaching the olfactory nerve ($p = 0.011$). Our results suggested that fibrin-gelatin fixation method can reduce the reported risk of anosmia. However, the possibility of olfactory nerve damage is relatively high when operating on brain tumors attaching olfactory nerve [18].

Lai et al. presented the operative experiences in a consecutive series of 103 patients with 115 unruptured AcomA aneurysms. Clinical results, operative complications, angiographic outcomes and prognostic factors associated with surgery are presented. Of the 115 aneurysm repairs attempted, 114 were treated by clipping or excision and suture. One aneurysm, less than 2mm, was wrapped. Six patients (5.8%; 95% confidence interval [CI], 2.5-12.4) experienced a new permanent neurological deficit. There was no postoperative mortality. Transient morbidity occurred in 11 patients (10.7%; 95% CI, 5.9-18.3), including transient anosmia (four patients), acute postoperative confusion and memory disturbances (four patients), extradural haematoma requiring surgery (two patients) and cerebrospinal fluid rhinorrhea (one patient). Of the 84 aneurysms (73.0%) that had documented postoperative angiography, 82 (97.6%) had complete obliteration of the aneurysm and two (2.4%) had neck remnants (mean angiographic follow-up 28.0 months; range, 1.6-146.4 months). Retreatment was performed in one patient (1.0%). Logistic regression analysis of risk factors revealed that aneurysm size ($p<0.01$) was a significant predictor of outcome. There was no incidence of subarachnoid haemorrhage in the 272 person years of follow-up. In the current study, surgical treatment of unruptured AcomA aneurysms resulted in 5.8% morbidity and no mortality. The robustness of aneurysm repair achieved by open microsurgery is an important consideration when considering the option between endovascular and microsurgical treatment for unruptured AcomA aneurysms. [19].

Nakayama et al. studied the incidence of postoperative infection related to Cerebrospinal fluid fistula and anosmia in basal interhemispheric approach (BIH). Between April, 1990 to March, 2009, 142 cases of anterior communicating (Acom) aneurysm including both unruptured and ruptured have been treated by clipping surgery using BIH. We retrospectively obtained clinical informations from medical records and video records about infectious complications, Cerebrospinal fluid fistula of cerebrospinal fluid (CSF), olfactory dysfunction and intraoperative findings of damage to the olfactory nerve. In most cases (139 patients, 97%), frontal sinus were opened at craniotomy. Of all, CSF

rinorrhea occurred in 4 cases (2.8%), and meningitis in 6 cases. There was only one patient who sufferd from meningitis due to CSF rinorrhea. All that patients recovered completely without deficit. Anosmia occurred in 6 cases (4.2%), and intraoperative injuries in 4 cases (2.8%). There was only one patient in whom anosmia was consistent with nerve injury. In conclusion, BIH is an appropriate procedure for infection risk control in Acom aneurysm surgery. It is difficult to avoid olfactory dysfunction completely, even if olfactory nerves are preserved in form. [20].

The horizontal head position was adopted in the unilateral anterior interhemispheric approach to treat an anterior communicating artery (ACoA) aneurysm. The patient was placed in the supine position. The patient's head was rotated to the right to orient the midline horizontally, and tilted 45 degrees superiorly. After bicoronal skin incision and bifrontal craniotomy, the dura on the right side (downside) was opened. Dissection of the right interhemispheric fissure allowed gravity to retract the right (downside) hemisphere, which fell away from the falx, while the falx supported the upside hemisphere. The present approach was used in three patients with ACoA aneurysm between January 2009 and April 2010. The aneurysms were adequately clipped with this approach. No complication related to the approach occurred. No patients exhibited anosmia after surgery. This approach is useful for ACoA aneurysms. [21].

Beseoglu et al. in 2003 introduced a minimally invasive transorbital keyhole approach. Because this approach requires removal of the orbital rim and orbital roof, there have been concerns regarding perioperative morbidity, long-term morbidity, and cosmetic results. The authors evaluated approach-related morbidity and cosmetic results in their patients to determine the rate of complications and compared this to published reports of similar approaches.

Material: Seventy-one patients (41 female, 30 male) underwent operations using this approach between 2004 and 2008. Immediate approach-related morbidity was recorded after the operation. Late morbidity was determined after 7 months by an independent examiner while cosmetic results were self-rated by the patient using a questionnaire.

Results: Fifty-one (72%) of 71 patients had no postoperative complications and 12 (16.9%) had minor complications, the most common of which was subgaleal CSF collection (7.0%). Other minor complications included facial nerve palsy (2.8%), hyposphagma (2.8%), periorbital swelling due to periorbital hematoma (2.8%), and subdural hematoma (1.4%). Major complications requiring surgical revision occurred in 4 patients (5.6%); these were CSF fistulas in 2 patients, pneumocephalus in 1 patient, and a hematoma in 1 patient. Forty-nine (90.7%) of all 54 examined patients rated the cosmetic results as very good or good. Major long-term morbidity was hyposmia or anosmia (14 patients) followed by hypoesthesia around the scar (9 patients).

The transorbital keyhole approach is a feasible approach with a low-risk profile for postoperative or long-term morbidity and excellent cosmetic outcome [22]

Although the frequency of smell disorders after the operations of the anterior communicating artery aneurysm depends to a large degree on the used surgical approach, several independent of surgery factors may contribute to the postoperative smell tests outcome. THE AIM OF OUR STUDIES: The

evaluation of the sense of smell in patients who underwent the operation of ruptured anterior communicating artery aneurysm using pterional approach.

Material and methods: In the retrospective studies the results of smell test of the group of 21 patients operated for ruptured anterior communicating artery aneurysm and 21 healthy volunteers of control group were compared. The patients suffering from neurodegenerative, metabolic and endocrynological disorders, as well as those with rhinoscopic symptoms of rhinosinusitis and with decreased nasal potency confirmed by anterior rhinomanometry were excluded from the study.

Results: During the operations it was possible to anatomically retain olfactory nerves in all operated patients. Severe smell disorders (severe hyposmia and anosmia) were detected in 1 (4.7%) patient of the control group and in 6 (28.5%) patients of postoperative group. The mean composite olfactory score in Cain test of the postoperative group was 4.53, and in the control group 5.47 points. The difference did not reach statistic significance (Mann-Whitney test, $p = 0.068$).

Conclusions: Although pterional approach to anterior communicating artery is relatively low traumatic to olfactory tract, the subarachnoid hemorrhage may have an unfavorable effect on postoperative olfactory nerve functioning. Considering the fact, that in spite of thorough examination of the patients, we were not able to exclude from the studied groups all the patients with preoperatively impaired smell, it seems reasonable to perform similar smell test studies in the prospective way [23)].

Bor et al. interviewed all patients who resumed independent living after SAH treated with coiling between 1997 and 2007. We assessed by means of logistic regression analyses whether risk of anosmia was influenced by site of the ruptured aneurysm, neurological condition on admission, amount of extravasated blood, hydrocephalus, and treatment for hydrocephalus.

Of 197 patients, 35 (18%; 95%CI:12 to 23) experienced anosmia. Anosmia had improved in 23 (66%) of them; in 20 the recovery had been complete after a median period of 6 weeks (SD +/-6.5). Intraventricular hemorrhage was a risk factor for anosmia (OR 2.4; 95%CI:1.0 to 5.9). Anterior aneurysm location (OR 1.1; 95%CI:0.5 to 2.3) and high amount of extravasated blood (OR 0.9; 95%CI:0.4 to 2.1) were not related to anosmia.

Anosmia occurs after coiling in 1 of every 6 SAH patients, but has a good prognosis in most patients. The cause of anosmia after coiling for ruptured aneurysms remains elusive; severity of the initial hemorrhage or long lasting hydrocephalus may be contributing factors. [24)].

Martin et al. studied whether and how frequently patients with ACoA aneurysms present with smell identification deficits in 2 treatment groups (endovascular and surgical treatment).

Methods: A prospective study was conducted of patients with SAH caused by ruptured ACoAs and who had a Glasgow Outcome Scale score of 1 or 2, in comparison with a control group matched by age and sex. Olfactory function was assessed using the University of Pennsylvania Smell Identification Test (UPSIT).

Results: A total of 39 patients were enrolled. A marked olfactory impairment was observed in patients with ruptured ACoAs compared with the control group ($p < 0.001$). Seventeen patients with ruptured ACoAs (44%) compared with 1 patient in the control group (3%) showed a smell identification deficit according to performance on the UPSIT ($p < 0.001$). Both groups that underwent treatment presented

with olfactory impairment. Ten (59%) of 17 patients who underwent aneurysmal clip placement versus 6 (28.5%) of 21 patients who underwent coil embolization scored below the 25th percentile on the UPSIT, and surgical patients also performed worse than endovascular patients (p = 0.048). The authors observed a worse performance on the olfactory test in patients subjected to endovascular coil embolization when cerebral vasospasm (p = 0.037) or frontal cerebral lesions (p = 0.009) were present. This difference was not observed in patients who underwent surgery.

Conclusions: Olfactory disorders after SAH caused by rupture of the ACoA are very frequent and were present in both treatment groups. Cerebral vasospasm and frontal lobe lesions are related to worse performance on an olfactory test in patients undergoing endovascular coil embolization [25].

To discriminate between the effects of aneurysmal rupture and treatment, Moman et al. assessed the occurrence of anosmia after clipping and coiling of unruptured aneurysms as well as after the coiling of ruptured aneurysms.

Methods: The authors interviewed patients in whom an unruptured aneurysm was treated by clipping (32 cases) or endovascular coiling (26 cases) as well as patients with SAH who underwent coil therapy (32 cases). A geographically defined subset of 20 patients per group was invited to undergo olfactory testing.

Results: Nine clip-treated patients (28% [95% CI 14-47%]) in the unruptured group reported having anosmia, and no coil-treated patient in the unruptured group (95% [CI 0-13%]) reported having anosmia; in the SAH group, 7 patients (22% [95% CI 9-40%]) reported having anosmia. Anosmia had improved over time in 3 of the clip-treated patients and in all but 1 of the patients with SAH. Examination revealed olfactory disturbance in 13 (65% [95% CI 41-85%]) of the clip-treated and 8 (42% [95% CI 20-67%]) of the coil-treated patients with unruptured aneurysms, and also in 7 (35% [95% CI 15-59%]) coil-treated patients with SAH. In 20 patients who underwent clip therapy for unruptured aneurysms, 19 (95% [95% CI 75-100%]) had olfactory dysfunction on the side ipsilateral to surgery (anosmia reported by 8 of them).

Conclusions: Both clip treatment and SAH contribute to the occurrence of anosmia, with different chances of improvement. Olfactory dysfunction occurs in almost all patients on the side of surgery and can occur subclinically after coil deployment. [26].

Wermer et al. studied the prevalence, predisposing factors (aneurysm site and type of treatment), impact, and prognosis of anosmia in patients with SAH.

Of the patients with SAH who resumed independent living, we included all patients treated by coiling between 1997 and 2003 and a sample of patients treated by clipping between 1985 and 2001. Patients underwent structured interviews regarding the presence and duration of anosmia. The impact of anosmia was scored using a visual analog scale ranging from 0 (no influence) to 100 (the worst thing that ever happened to them). Risk factors for anosmia were assessed by logistic regression analysis.

Overall, 89 of the 315 interviewed patients (28%; 95% confidence interval [CI], 23-34%) reported anosmia after SAH (mean follow-up period, 7.4 yr), including 10 (15%) of the 67 coiled patients and 79 (32%) of the 248 clipped patients. The median visual analog scale impact score was 53 (range,

0-100). In 20 of the 89 patients (23%; 95% CI, 15-33), the symptoms had improved over time. Risk factors for anosmia were treatment by clipping (odds ratio [OR], 2.7; 95% CI, 1.3-5.7) and anterior communicating artery aneurysms (OR, 2.0; 95% CI, 1.2-3.3).

Anosmia after SAH has a high prevalence, considerable impact, and poor prognosis. Its occurrence after coiling suggests not only damage to the olfactory nerve by clipping but also that the SAH itself plays a role in its pathogenesis. [27)]

Nozaki et al. described a patient with bilateral persistent primitive olfactory arteries associated with an unruptured saccular aneurysm on the left persistent primitive olfactory artery. Seven reported cases with this anomalous artery including ours are reviewed and classified into two variants. This anomalous artery arises from the terminal portion of the internal carotid artery and courses anteromedially along the ipsilateral olfactory tract and makes a hair-pin curve posterior to the olfactory bulb, becoming the distal anterior cerebral artery (variant 1) or the ethmoidal artery (variant 2). Out of 7 reported cases, 4 cases are associated with saccular aneurysms. The aneurysm in variant 1 is located on the hair-pin curve at which an apparent arterial branch is sometimes absent. Two patients suffer from anosmia. Persistent primitive olfactory artery should be kept in mind because of its high association with intracranial saccular aneurysms and unique clinical presentation. [28)].

In as retrospective study, 100 patients with anterior communicating artery aneurysms, for whom the pterional approach was employed, were observed from the point of view of postoperative olfactory nerve function. In the postoperative period only three cases suffered from the impaired sense of smell ipsilateral to the side of surgery. 15 patients objectively showed olfactory nerve distinctions. The functions of olfactory nerve could be preserved at a relatively high rate of 85 per cent. This high rate resulted from the microtechnique employed as well as the relatively cautious frontal lobe retraction which was less than 1.5 cm. [29)].

Between 1969 and 1994 we treated 450 patients with ruptured anterior communicating artery aneurysms, of which 434 cases (96.4%) were operated on via the interhemispheric approach (IH), namely, until 1979 mainly, via bifrontal craniotomy, subfrontal and interhemispheric approach (SIH) and, since 1979, via posterior interhemispheric approach (PIH). Postoperative olfactory dysfunction is one of the main disadvantages of IH. The mechanisms and the incidence of this disadvantage were studied in both approaches. The causes of postoperative anosmia in SIH were as follows: sectioning of olfactory tracts intentionally or not, avulsion of olfactory bulbs and probability of ischemic or minor mechanical insults to olfactory tracts. However, these matters rarely occur in PIH because of little exposure of olfactory nerves. The mechanisms of postoperative anosmia in PIH were considered to be as follows: sinking of frontal lobes due to excessive drainage of cerebrospinal fluid and over-retraction of frontal lobes. The incidence of postoperative anosmia decreased from 27.0% via SIH to 5.5% via PIH [30)].

The olfactory function could be examined in 101 of 138 patients with anterior communicating artery aneurysms, whom we treated during a recent 6-year period. Among them, 49 patients underwent surgery by the anterior interhemispheric approach and 52 underwent surgery by the basal

interhemispheric approach. Fifteen patients (31%) exhibited anosmia after surgery by the anterior interhemispheric approach, whereas only one patient (1.9%) exhibited anosmia after surgery by the basal interhemispheric approach. Unilateral dural incision and unilateral brain retraction without elevation of the frontal lobe from the frontal base are important, because frontal lobe depression and elevation during surgery may injure the olfactory nerve [31].

Yasui et al. reviewed the surgical outcome in 85 patients with ruptured anterior communicating artery (ACoA) aneurysms, who were operated on within 72 hours of onset via a basal interhemispheric (BIH) approach (Group 1, N = 48), or an anterior interhemispheric (AIH) approach (Group 2, N = 37). The age, sex ratio and pre-operative grade (Gr) were similar for both groups. The outcome at the time of discharge was as follows for group 1: excellent or good 88%; fair, 6%; vegetative state, 2% and death 4%. For group 2, it was: excellent or good 78%; fair, 16%; vegetative state, 3%; and death, 3%. A significant correlation between admission grade and outcome was found in both groups. The outcome in group 1 was better than in group 2 for patients with a Glasgow Outcome Scale (GOS) better than fair ($p < 0.07$). No patient in group 1 had postoperative anosmia, but nine patients in group 2 became anosmic. The total number of complications was also significantly less in group 1. Our overall mortality rate was 4%. In conclusion, the BIH approach was more beneficial for treating acute ACoA aneurysm. [32].

In a retrospective study of 25 patients operated on for ruptured intracranial aneurysms via the frontotemporal route, 22 patients suffered postoperatively from anosmia ipsilateral to the side of surgery. This complication most often goes unrecognized by the patient as well as the physician, and attention should be drawn to it because of its widespread occurrence. This investigation demonstrates a high incidence of anosmia (24 (88.9%) of 27 surgical sides) occurring ipsilateral to the frontotemporal approach in aneurysm surgery. Recovery after traumatic anosmia has been recorded up to 5 years after injury. Nevertheless, the authors believe that the damage is permanent when lasting 35 months or longer [33]

Results of surgical treatment of anterior communicating artery aneurysms, approached via bifrontal craniotomy, are reported in 110 cases. It was possible to preserve the olfactory tracts bilaterally or unilaterally in over 65% of these cases: 47% with bilateral preservation and 34% with unilateral preservation; 33% of the patients with bilateral olfactory tract damage reported subjectively normal olfactory. Objective examination of olfaction by an otolaryngologist showed that 84% of the patients reporting normal olfaction did indeed have normal olfaction, whereas 91% of these reporting no olfaction were anosmic [34].

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