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Perioperative Complications in Acoustic Neuroma (Vestibular Schwannoma) Surgery

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Objective: Retrospective study and review of the complications other than those related to the facial nerve and hearing, encountered in acoustic neuroma surgery. Also, an evaluation of hospital stay and its relation with various factors.

Study Design: Retrospective case review.

Setting: Tertiary neurotologic and skull base referral center.

Patients: A series of 707 patients who underwent surgical removal of acoustic neuroma from April 1987 to December 2001.

Interventions: The surgical approaches used were the enlarged translabyrinthine approach, the enlarged middle fossa approach, and the retrosigmoid approach. In a small number of cases, the operations were performed through other approaches.

Main Outcome Measures: The duration of hospital stay and appearance of complications in the perioperative period along with their management. Results related to the facial nerve and hearing were not considered in this study.

Results: The most frequent complication was abdominal subcutaneous hematoma (site of fat harvest), which occurred in 23 patients (3.2%). Cerebrospinal fluid leak was present in 20 patients (2.8%), 15 of whom needed revision surgery. Other complications included VIth cranial nerve dysfunction in 12 cases (1.68%), subdural hematoma in 3 cases (0.4%), cerebellopontine angle hematoma in 4 cases (0.6%), cerebellar edema in 2 cases (0.28%), brainstem hematoma in 1 case (0.14%), transitory aphasia in 1 case (0.14%), and lower cranial nerve dysfunction in 1 case (0.14%). Mortality occurred in only one case (0.14%). Medical complications seldom occurred. The postoperative hospital stay ranged from 2 to 36 days, with an average of 6.4 days. The overall hospital stay diminished over time from 10.2 days in 1987 to 1990, to 4.9 days in 2001. There was a significant relation between hospital stay and tumor size, approach used, and presence/absence of complications.

Conclusions: Perioperative complications in acoustic neuroma surgery do exist, but this study demonstrated how low the incidence is. The authors believe that the low percentage of complications is mainly attributable to the majority of operations being carried out in specialized clinics, where they are considered routine operations. They believe that following individualized approaches, depending on tumor size and on the preoperative function of the cranial nerves, is the proper way to reach a significant reduction in complications while maintaining a high percentage of total tumor removal. The results of this study, considered as a basis of comparison with other studies, will certainly be useful in preoperative patient counseling. **Key Words:** Acoustic neuroma surgery—Surgical complication—Translabyrinthine approach—Vestibular schwannoma.
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Acoustic neuromas (ANs) (vestibular schwannomas) are histologically benign tumors that originate from the Schwann cells of the VIIIth cranial nerve. These tumors generally develop slowly and tend to compress the adjacent neurovascular structures. They usually present to the physician with symptoms affecting the VIIIth cranial nerve, such as tinnitus, hypoacusis (often progressive sensorineural hearing loss/deafness), balance disorders, rarely trigeminal symptoms, and paralysis of the VIIth cranial nerve in a low percentage of cases. Microsurgical removal is the best treatment of these tumors. The aim of surgery is to totally remove the abnormality and reduce the chances of complications. The most frequent complications associated with AN surgery involve both the facial and cochlear nerves, but other complications, which might arise during or after surgery, can somehow affect the quality of the patient's life. Currently, three approaches are mainly being used for the removal of AN (1):

1. The enlarged translabyrinthine approach (ETLA), which allows the total removal of the majority of tumors independent of their size, anatomically preserving the facial nerve and associated with partial or no cerebellar retraction.
2. The retrosigmoid approach (RSA), a routine operation in the field of neurosurgery for the removal of various sized acoustic neuromas.
3. The enlarged middle fossa approach (EMFA), performed for the removal of intracanalicular tumors and/or with extrameatal extension of 0.5 cm.

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The choice of the proper approach, that totally removes the AN, depends on the size of the tumor, which is a matter of primary importance. In our center, we adopt an individualized strategy, based on the tumor size, the presence of the tumor at the fundus of the internal auditory canal (IAC), and the preoperative hearing level in addition to considering the patient's age and also his or her contralateral hearing. We perform the EMFA in cases of intracanalicular tumors with a maximal extrameatal extension of 0.5 cm, endowed with a hearing better than 25 dB (in the range of 0.5–4 KHz), and a speech discrimination score greater than or equal to 80%. Elderly patients with a poor general status are unlikely candidates for this operation. For the same hearing level and the same discrimination score level in extrameatal tumors up to 1 cm that do not reach the fundus of the IAC, on a patient younger than 60 years of age, we adopt the combined retrosigmoid-retrolabyrinthine approach. For all other tumors, regardless of size, age, and hearing level, we perform ETLA. Although for tumors with an extrameatal diameter less than or equal to 1 cm, hearing preservation is a realistic possibility by performing a total removal with facial nerve conservation, for tumors of greater size the prospect of hearing preservation is extremely rare, so this does not influence our surgical decision (2). In our center, we adopt ETLA as a routine operation for large tumors also. So far, none has been too large to cause failure of removal. This outcome confirms the thesis upheld by Lanman et al. (3).

At the beginning of the last century, the mortality rate in acoustic neuroma surgery was 80%. Through the years, mostly in specialized centers, because of experience, mortality rates have remarkably decreased to less than 1%. Currently, the main aim of surgical treatment in our center is based on the following principles, listed by priority:

1. Total tumor removal with minimal mortality and morbidity.
2. Total tumor removal to reduce risk of residual tumor.
3. Conservation of the facial nerve.
4. Hearing preservation, when possible.

These principles can be achieved by choosing the proper individualized surgical approach. This implies that the surgical team must be able to perform all surgical procedures.

In spite of the improvements in microsurgical techniques, the adoption of an individualized strategy, the routine use of VIIth and VIIIth cranial nerve monitoring, and modern anesthetic methods, serious intra- and postoperative complications still exist. The aim of this study was to examine the complications associated with AN surgery other than the VIIth and VIIIth cranial nerve outcome, which are directly related to the removal of the tumor itself. These could be hematomas, cerebrospinal fluid (CSF) leaks, brain edema, meningitis, mortality, and others. The complications reported in previous large case series are used as a basis of comparison by the authors, and they can certainly be useful for the purpose of preoperative counseling. Moreover, there is the need to know whether our individualized surgical strategy is justified by the results achieved and whether there are any differences in the percentages of the complications related either to surgical approach or to tumor size. This retrospective study also serves to identify the existence of those surgical steps that might contribute to postoperative complications, so that they can be discarded. The last aim of this study was to evaluate the duration of hospital stay in AN surgery and its relation to various factors such as tumor size, approach used, and absence/presence of complications.

PATIENTS AND METHODS

Hospital charts of all the patients operated on in our center from April 1987 to December 2001 were examined retrospectively. All preoperative, intraoperative, and postoperative surgical data were registered in a computerized database and analyzed. All 707 operations were performed by the senior author (M.S.) with a neurotologic team.

Patient age ranged from 13 to 80 years, with an average of 49.3 years. The most commonly used approach was ETLA, performed on 600 patients (84.9%), followed by the EMFA on 54 patients (7.6%), the combined retrolabyrinthine-retrosigmoid approach on 38 patients (5.4%), and other approaches for the remaining 15 patients (2.1%). As shown in Figure 1, the number of operations performed annually progressively increased. The use of the retrosigmoid approach combined with a retrolabyrinthine mastoidectomy proportionally increased, whereas the percentage of EMFA remained stable during the last years.

A majority of the patients (684 [96.7%]) underwent a primary operation, but 23 (3.3%) were operated on for a residual tumor. These patients had already undergone one or more surgical interventions at other centers (4,5).

Average tumor size was 1.84 ± 1.21 cm (range, intracanalicular–5.4 cm). Tumor size was evaluated as the maximal extrameatal diameter on magnetic resonance imaging. Distribution of tumors according to size was as follows: intracanalicular, 80 cases; 0.1 to 1 cm, 83 cases; 1.1 to 1.9 cm, 207 cases; 2.0 to 2.9 cm, 162 cases; 3.0 to 3.9 cm, 130 cases; and greater than or equal to 4 cm, 45 cases.

Including patients over 70 years of age, tumor removal was complete in 667 cases (94.3%) and planned partial in 33 cases (4.7%) to avoid facial nerve paralysis; there were 5 cases (0.7%) of unplanned subtotal, because of the changes in vital

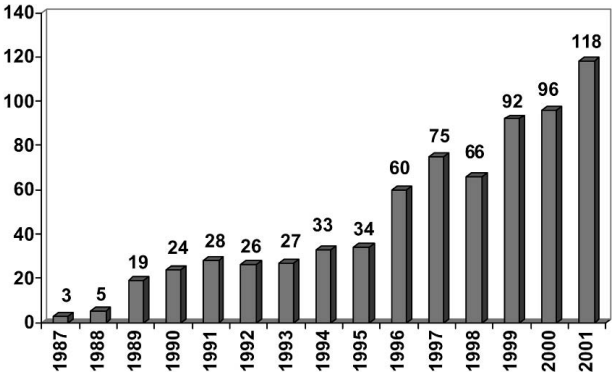

FIG. 1. Number of operations over the years.

signs during the dissection of the tumor capsule from the brainstem and 2 (0.3%) staged removal cases caused by profuse bleeding (patients who were being operated on for the second time for complete removal of the tumor).

The statistical tests used for ascertaining significance were the Fisher's exact test (two-sided), unpaired *t* test, one-way analysis of variance with Tukey Kramer multiple comparison test, and χ^2 test with Yates' correction. The value of *p* was set at 0.05 as statistically significant. The statistical software used was GraphPad InStat, version 3.05 for Windows 95 (GraphPad Software, San Diego CA, U.S.A.).

RESULTS

Postoperative hospital stay

The duration of postoperative hospital stay is not frequently reported in the literature (6,7), even though it truly shows the morbidity arising from the surgical intervention. In addition, because of the increasing attention to the reduction of health expenditure in all countries, this parameter is gaining more and more importance. Average duration of hospital stay of the series was 6.4 ± 3.42 days (range, 2–36 days). The overall hospital stay diminished over time from 10.25 ± 4.11 days (range, 7–30 days) in 1987 to 1990, to 4.94 ± 2.14 days (range, 3–22 days) in 2001 (Fig. 2).

Hospital stay was longer in case of tumors with an extrameatal diameter greater than or equal to 3 cm. However, to evaluate better the statistical relationship between tumor size, we considered only those cases that were operated on using ETLA with no complication to rule out any bias. Tumors less than or equal to 2.9 cm were considered as one group and tumors greater than or equal to 3 cm as another. The average hospital stay for the first group was 5.7 ± 2.6 days (range, 2–36 days), and the same for the second group was 6.5 ± 2.63 days (range, 3–23 days). The difference between the two groups was statistically very significant (two-tailed $p = 0.0021$, unpaired *t* test). The surgical approach used also determined the duration of hospital stay. To evaluate this aspect, we considered tumors less than or equal to 1 cm for ETLA to make the group comparable with RSA and EMFA because we use these two approaches for such tumors only. Also, any tumor with a postoperative complication was removed from the group. The average hospital stays for ETLA, RSA, and EMFA were 5 ± 1.77 days (range, 2–11 days), 6.7 ± 2.99 days (range, 3–13 days), and 6.9 ± 2.99 days (range, 3–12 days), respectively. Statistically, this difference in stay was extremely significant ($p < 0.0001$, one-way analysis of variance with Tukey Kramer multiple comparison test). The difference between RSA and EMFA was not statistically significant ($p = 0.7626$, unpaired *t* test).

Average duration of hospital stay for patients with surgical complications was 10.3 ± 6.25 days (range, 3–30 days). Again, when this was compared with the hospital stay of patients without complications, which was 6 ± 2.64 days (range, 2–36 days), the difference was statistically extremely significant (two-tailed $p < 0.0001$, unpaired *t* test). While evaluating these particular data, all patients requiring readmission after discharge were excluded from the group. This included 10 patients: 4 for CSF leak, 3 for subdural hematoma, 1 for meningitis (occurring after 5 years), 1 for lateral sinus thrombosis, and 1 for subcutaneous CSF collection. The hospital stay in patients with CSF leak and subcutaneous abdominal hematoma was also compared individually to the group without any complications. The average hospital stay for these two groups was 12.4 ± 5.7 days (range, 3–26 days) and 7.6 ± 3.12 days (range, 3–16 days), respectively. The difference for both complications when compared with the hospital stay of the group without complications was statistically significant (CSF leak, $p < 0.0001$; hematoma, $p = 0.0047$, unpaired *t* test).

Surgical complications

Table 1 and Table 2 list the surgical complications. The most frequent complication was subcutaneous ab-

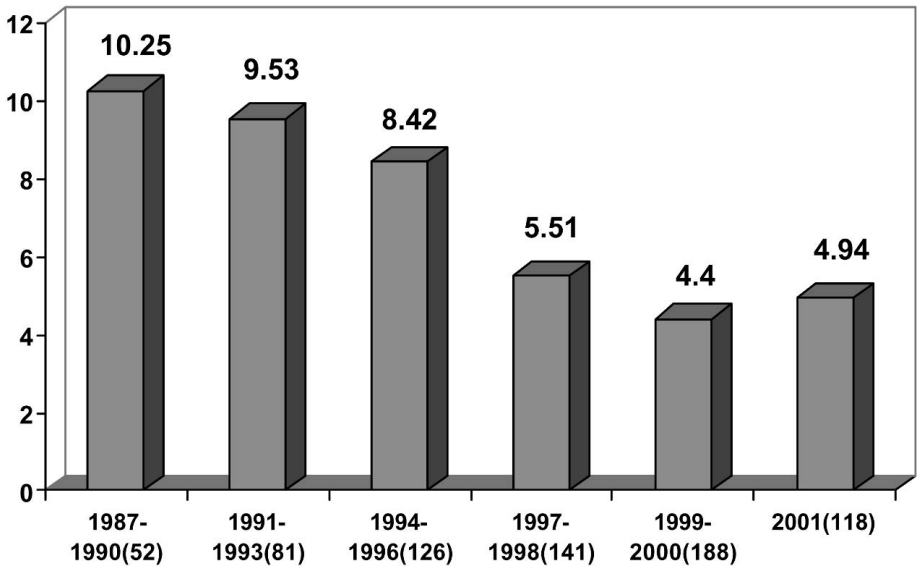

FIG. 2. Hospital stay over the years. Numbers in parentheses indicate the number of patients.

TABLE 1. *Major complications*

	No. (%)
CSF leak	20 (2.8)
Requiring operation	15 (2.1)
Treated conservatively	5 (0.7)
Cerebellopontine angle hematoma	4 (0.6)
Subdural hematoma	3 (0.4)
Subarachnoid hemorrhage	1 (0.14)
Brainstem hematoma	1 (0.14)
Subcutaneous CSF collection	1 (0.14)
Lateral sinus thrombosis	1 (0.14)
Death	1 (0.14)
Cerebellar edema	2 (0.28)
Meningitis (after 5 yr)	1 (0.14)
Hemiplegia	1 (0.14)
Lower cranial palsy (vagus)	1 (0.14)

CSF, cerebrospinal fluid.

dominal hematoma (at the site of fat harvest), followed by CSF leak.

The average size of the tumors that had complications was 2.3 cm, ranging from intracanalicular to 5 cm extrameatal. Table 3 lists the complications ranked by tumor size. The incidence is much higher in tumors having an extrameatal diameter greater than or equal 3 cm compared with the smaller tumors (22.3% for tumors between 3 and 3.9 cm and 20% for those >4 cm). The difference in the incidence of complications between tumors less than 3 cm and greater than or equal to 3 cm was statistically extremely significant (two-sided $p < 0.0001$, Fisher's exact test).

Subcutaneous abdominal hematoma

In 23 patients (3.2%) operated on via the ETLA, subcutaneous abdominal hematoma arose at the site of fat harvest. All of them were treated by reopening the abdominal wound and draining the hematoma. No sequelae were observed after the above treatment.

CSF leak

Cerebrospinal fluid leak is one of the most important postoperative complications in AN surgery because it might lead to meningitis. In our series, it occurred in 20 of 707 cases (2.8%): 11 of 600 cases (1.8%) in which ETLA was performed, 7 of 38 cases (18.4%) that underwent RSA, and 2 of 54 cases (3.8%) operated on via EMFA. The difference in the incidence of CSF leak between ETLA and RSA was statistically extremely significant (two-sided $p < 0.0001$, Fisher's exact test). It did not occur in retrolabyrinthine, transotic, and transcochlear approaches.

TABLE 2. *Minor complications*

	No. (%)
Subcutaneous abdominal hematoma	23 (3.2)
Transitory cerebellar disturbance	10 (1.4)
VIth cranial nerve palsy	12 (1.6)
Transient	10 (1.4)
Definitive	2 (0.28)
Transitory aphasia	1 (0.14)
Trigeminal neuralgia	2 (0.28)
Subcutaneous infection	1 (0.14)

TABLE 3. *Distribution of dimensions of tumors with complications*

	No. (%)
Intracanalicular	5/80 (6.2)
0.1–0.9 cm	8/83 (9.6)
1–1.9 cm	16/207 (7.7)
2–2.9 cm	11/162 (6.8)
3–3.9 cm	29/130 (22.3)
>4 cm	9/45 (20)

Usually, the insertion of a lumbar drain helps in controlling the leak. If not, then the patient needs to undergo revision surgery, prolonging his or her hospital stay. In our study, 15 of the above 20 patients had to be operated on for closure of the leak, whereas the remaining 5 were managed conservatively. The surgery entailed reopening the wound and adding more abdominal fat tissue in cases of ETLA, whereas in RSA, the external auditory canal was closed as a cul-de-sac and the eustachian tube obliterated.

The introduction of intraoperative refinements, already published (8), has progressively reduced the incidence of CSF leak in the translabyrinthine approach. In fact, between August 1994 and December 2001, it occurred in only 2 of a total of 376 patients operated on using ETLA during this period, an incidence of only 0.53%. To our knowledge, this is the lowest incidence ever reported.

Over time, the overall incidence of CSF leak has diminished from 9.6% during the period between 1987 and 1990 to 3.4% in 2001 (Fig. 3). The slight increase of CSF leak in 2001, in comparison with the 1994 to 2000 period, is attributable to the more frequent use of the RSA.

Cerebrospinal fluid leak usually occurs through the retrolabyrinthine or the apical cells. To avoid this complication, it is imperative that all the cells should be obliterated. To achieve this goal, particularly in RSA, we perform a mastoidectomy, remove all the retrolabyrinthine and apical cells, and then obliterate the mastoid cavity using abdominal fat. Attention should also be paid to the posterior wall of the IAC. Any small cell there can be obliterated using bone wax. We frequently use an endoscope to visualize any cell capable of producing a leak but not visible directly and make sure that it is taken care of (9). However, to draw any statistically significant conclusion about the positive results of this treatment, we need to have a greater number of patients. The average size of tumors with CSF leak was 1.52 cm, ranging from intracanalicular to 3.4 cm extrameatal, whereas the average size of tumors without CSF leak was slightly larger (1.85 cm), ranging from intracanalicular to 5.4 cm extrameatal.

Meningitis

Meningitis is one of the complications reported in the literature. It is mentioned in our study because it oc-

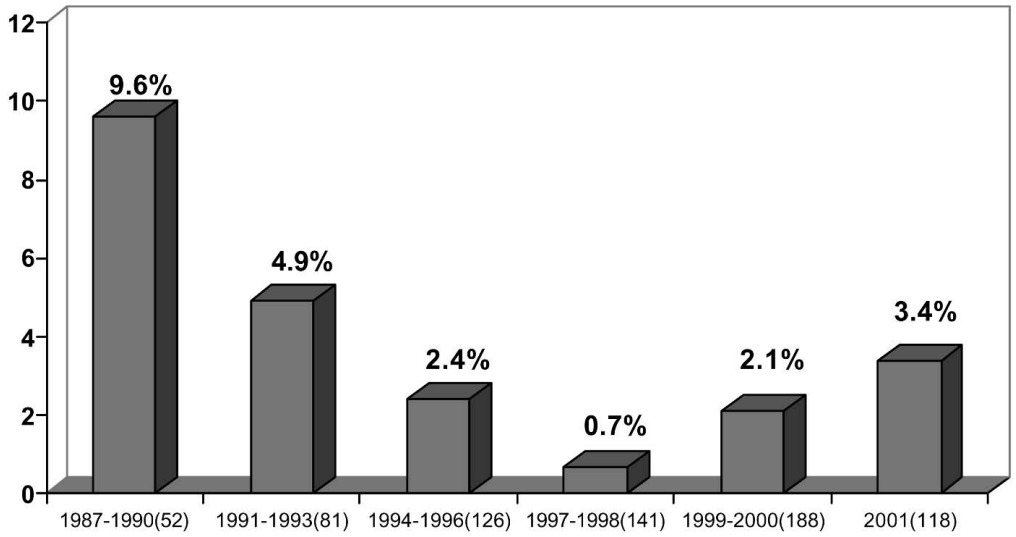

FIG. 3. Percentage of CSF leak. Numbers in parentheses indicate the total number of patients during that period.

curred in only one patient 5 years after having undergone the RSA (0.14%). We normally use perioperative and postoperative antibiotic treatment (2 g of piperacillin every 4 hours) for 48 hours or we extend the therapy for another 48 hours if the operation has lasted longer than 8 hours.

Death

Only one case of mortality is reported (0.14%). The patient was a 67-year-old man with a particularly vascular tumor that was 3 cm in size. Profuse bleeding occurred into the cerebellopontine angle (CPA), extending to the ventricles, causing an irreversible coma and finally leading to the death of the patient. This happened in spite of an early ventricular shunt.

Intracranial hemorrhage

Intracranial hemorrhage occurred in nine patients: four of them had CPA hematoma (including the patient who died), three had subdural hematoma, one had subarachnoid hemorrhage, and one had intraparenchymatous hematoma of the brainstem. Subarachnoid hemorrhage occurred in the patient 48 hours after surgery and a cerebrospinal fluid shunt was necessary.

Hematoma of the brainstem affected a 40-year-old woman: her tumor was larger than 4 cm. The patient underwent computed tomographic (CT) scanning, magnetic resonance imaging, and medical therapy. She maintained a modest ataxia and hemianesthesia for 3 months and was eventually able to ambulate autonomously after physical therapy. The woman was hospitalized for 15 days.

Cerebellopontine angle hematoma occurred in four cases (0.6%). In all cases, it occurred within the first 12 hours after surgery: it was surgically removed in two (one of which presented a modest hemiplegia for approximately 6 months), with total resolution, whereas it was managed with medical treatment and ventricular shunt in the third case. In the last case, the hemorrhage spread to the ventricles, as mentioned previously, leading to the death of the patient.

Subdural hematoma was observed in three patients after 7, 10, and 40 days, respectively. Because of their early rehospitalization, constant and timely observations monitored by CT scanning, and proper medical therapy, there were no neurologic deficits reported.

Lateral sinus thrombosis

Lateral sinus thrombosis occurred in one patient (0.14%) 10 days after surgery, causing a progressive deterioration of the homolateral vision. She was given heparin and monitored, but no intervention was performed. The final outcome cannot be reported, as the patient was lost to follow-up.

Cerebellar edema

Cerebellar edema occurred in two cases (0.28%). The patients had been operated on via the RSA. Both were treated with diuretics and cortisone until the symptoms disappeared.

In 10 patients, specific symptoms suggesting cerebellar edema were not observed, although evidence of mild cerebellar transitory disorders was present. In all cases, symptoms disappeared after steroid therapy.

Transitory aphasia

This occurred in one case. The patient was a 26-year-old woman with a 5.6-cm residual tumor. She had been operated on at another center. After the first operation, the patient was severely incapacitated neurologically and confined to a wheelchair. She also had a Grade VI facial paralysis. We performed the revision surgery using a modified transcochlear transzygomatic approach with

complete tumor removal. We also performed a XIIth-to-VIIth cranial nerve anastomosis for the facial paralysis. The patient had aphasia that lasted for 10 days and then disappeared without any specific treatment.

Complications of the cranial nerves

This study reports only one case of permanent lower cranial nerve paralysis. The nerve affected in this particular case was the vagus. Over time, this was compensated for by the nerve of the opposite side. Twelve patients had VIth cranial nerve paralysis, 10 of which recovered completely and 2 of which had partial recovery. These two required no intervention, and any visual deficit was overcome using corrective glasses. Two patients developed a severe trigeminal neuralgia that did not resolve with medical therapy.

Medical complications

It is significant that serious postoperative medical complications were almost absent. We did not have to deal with pulmonary complications, problems of the urinary tract, or general sepsis. We believe that the absence of medical complications is attributable to the routine antibiotic therapy administrated during the 48-hour perioperative period, which may be prolonged if the intervention lasts longer than 8 hours. Another reason is that extubation is performed as the patient is awakened, has his or her urinary catheter removed after 12 hours, and is ambulated after 24 hours.

DISCUSSION

This study focuses on the complications (morbidity and mortality) specifically associated with AN surgery, whereas other specific complications involving the VIIth and VIIIth cranial nerves, usually present after the removal, are excluded on purpose. Very few studies have been published relating to complications arising from AN removal, especially when considering large series (10–12), and there are only a few documented studies on surgical and medical complications (13–18). Acoustic neuroma surgery is normally performed by a team of neurotologists and neurosurgeons, but in our center, the team consists exclusively of neurotologists.

Postoperative CSF leak is the most frequent serious complication in AN surgery. It is a very serious complication because it might lead to the development of meningitis or the patient might need a spinal drain. Some cases may even require a revision operation as pointed out earlier. In our series, the total number of cases with CSF leaks was 20 (2.8%): 15 underwent surgery for leak closure (2.1%). The occurrence of CSF leak has progressively diminished over the years (from 9.6% in 1987 to 3.4% in 2001). This percentage is much lower if we only consider ETLA during the past 5 years: just 2 cases of 376 (0.53%). In our knowledge this is the lowest incidence ever reported in the literature. These results are attributable to the introduction of specific technical refinements (8). These advancements consist of the systematic use of mastoid periosteal tissue instead of fat to close the attic and the middle-ear in addition to inserting strips of abdominal fatty tissue in the CPA and obliterating every retrolabyrinthine and apical cell. If the apical cells cannot be seen directly, they can be plugged with bone wax using an endoscope. The subcutaneous tissue and the skin are sutured on different levels, and a compressive bandage is applied for at least 6 to 7 days.

In the literature, the incidence of CSF leak varies from a minimum of less than 4% to greater than 30%. In 1994, Hoffman (14) reported in his study the incidence of CSF leak as 27% in cases operated on via the ETLA. In a study based on the Acoustic Neuroma Registry by Weigand et al. (15), the reported incidence of CSF leak in ETLA is 11.1%. In a recent work by Slattery et al. (10) consisting of 1,225 patients operated on via the ETLA, the rate was 9.4%, 2.1% of which underwent reoperation. In the series of Bryce et al. (19), the incidence reported was 11% in ETLA. We compared each of these series with our results of CSF leak in ETLA individually. In each case, the difference was statistically extremely significant with the two-sided $p < 0.0001$ in each case (χ^2 test with Yates' correction).

Slattery et al. (10) found a direct relationship between tumor size and CSF leak incidence, with the incidence being higher in larger tumors. Others have also demonstrated the same relationship (19). On the contrary, there have been studies that did not confirm this relationship (8,14). Our study did not demonstrate this relation either. In fact, in our study, overall CSF leak was more likely to arise in smaller tumors with an average size of 1.5 cm or smaller (range, 0–3.4 cm) than in a larger tumor with an average size of 1.85 cm (range, 0–5.4 cm). We feel that the explanation for this conflicting finding lies in the choice of approach. Many of these small tumors were removed via the RSA. As mentioned earlier, the risk of CSF leak is more with the RSA as compared with the other approaches. This can be further minimized using some extra surgical steps as detailed earlier.

In ETLA with CSF leak that lasts more than 48 hours, even after managing with a lumbar drain, we do not hesitate in reoperating quickly to add further abdominal fatty tissue and thus avoid the risk of meningitis. The same principle is also followed in RSA when hearing is not preserved. In these cases, a subtotal petrosectomy is performed with the eventual cul-de-sac closure of the external auditory canal. The lumbar drain is useful in cases of a modest CSF leak either in ETLA or in RSA that have preserved hearing. In every case, a 6- to 7-day postoperative compressive bandage is used.

In our series, as mentioned above, the occurrence of meningitis is very low: 1 of 707 cases (0.14%); it occurred in the patient 5 years after RSA. Slattery et al. (10) reported an incidence of 1.5% of meningitis, a higher rate than those with CSF leak (two-sided $p < 0.0076$). Mass et al. (12) showed an incidence of 1.6% of bacterial meningitis in ETLA (two-sided $p = 0.0284$). Bryce et al. (19) presented a rate of 2.6% (two-sided $p = 0.0002$)

and Wiegand et al. (15) reported approximately 2.5% (two-sided $p = 0.0002$). Using the middle cranial fossa approach, Kanzaki et al. (20) reported a very high percentage of 19% (two-sided $p < 0.0001$). A statistical comparison of our results with the others showed an extremely significant difference in each case using χ^2 test with Yates' correction. In our opinion, our incidence is very close to zero because of the low rate of CSF leak and because of the quick revision in patients who had CSF leak within 48 hours after surgery, preventing the possibility of infection from the respiratory tract or the lumbar drain.

In our center, to prevent further contamination, the fat tissue is harvested after tumor removal and kept in an antibiotic solution until its insertion in the surgical cavity. This reduces the time that the abdominal fat stays out of the body. Moreover, a routine postoperative antibiotic therapy is administered for 48 hours; however, if the operation lasts longer than 8 hours, antibiotic treatment is continued for another 48 hours.

The most serious postoperative complication is intracranial hemorrhage causing progressive deterioration of consciousness, a symptom that requires urgent management. The delay in the recognition of symptoms causes compression, followed by brainstem and cerebellar edema, finally leading to coma. Intracranial hemorrhage occurred in nine patients (1.3%).

Cerebellopontine angle hematoma usually occurs within the first 24 hours (even though it appeared within 12 hours in all four cases). In the intensive care unit, it is possible to reduce the compression by opening the wound and extracting the abdominal fat, without CT scan confirmation. This procedure gives us valuable time to prepare the patient for surgery for the definite removal of the hematoma. If this complication is immediately treated, other problems can be avoided. On the contrary, an intraventricular hemorrhage requires a CSF shunt, even though in one of our cases it was not resolved. It is not possible to operate on an intraparenchymal hemorrhage, even though it might lead to very serious neurologic consequences requiring long-term medical treatment.

After removing the tumor, continuous suction-irrigation is necessary for at least 10 minutes to achieve hemostasis while waiting for the anesthesiologist to raise arterial pressure to its initial level. At the end of the operation, the anesthesiologist is requested to increase venous pressure by applying the Valsalva maneuver. It is possible to raise the venous pressure by increasing the current volume of the respirator, which in turn raises the intrathoracic pressure and causes a stagnation of the venous blood, allowing us to check whether there is a possible venous hemorrhage. During the first 24 to 48 hours, continuous postoperative neurologic monitoring is extremely important. For this reason, in our center, the patient is always awakened and extubated as soon as the intervention is over. The deterioration in the patient's consciousness is the most reliable clinical parameter for recognizing the appearance of a CPA hematoma.

All four cases of CPA hematoma in our series occurred after the removal of large tumors. Samii and Matthies (11) reported an incidence of 1.7% in 1,000 neuromas (two-sided $p = 0.0613$). In a recent work by Slattery et al. (10), an incidence of 0.9% of a total number of 1,687 patients is reported (two-sided $p = 0.5748$) (10). Our results are comparable to those large series (4 of 707 [0.6%]), although the difference is not statistically significant using χ^2 test with Yates' correction.

As far as general medical complications are concerned, they are almost absent, being more frequent in other centers, especially involving infection of the urinary tract (6). In our opinion, complications of the pulmonary system, including embolism, do not arise because of early postoperative ambulation and the use of compression boots from the moment they are being operated on to the moment they start walking.

CONCLUSION

In this series, the incidence of postsurgical complications for patients operated on for AN removal is very low, specially in relation to CSF leak, which is considered the most dangerous among the complications. The low rate is attributable to the experience acquired by regularly performing surgery on these patients. This way, it was possible to develop a series of technical refinements for the classic translabyrinthine approach, which permitted the removal of even large neuromas, without significant differences from the small ones. The same is also true for intracranial hemorrhages.

The results reported in our study show that the experience gained from the large number of interventions performed in highly specialized centers drastically minimizes morbidity and hospital stay. Certainly, it is important to admit to the possibility of serious complications; therefore, it is necessary to identify them as soon as possible to reduce catastrophic consequences.

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