Int. Adv. Otol. 2010; 6:(2) 141-148

ORIGINAL ARTICLE

Tumor Size and Foramen Luschka in Vestibular Schwannoma Surgery

Juraj Koval, Silvia Krempaská

University of P.J. Safarik, Faculty of Medicine, L. Pasteur University Hospital, Department of Otorhinolaryngology Head & Neck Surgery, Kosce, Slovakia

Objective: The aim of this work is to document how the situation in the foramen Luschka region influences our indication of translabyrinthine and retrosigmoid approaches in the treatment of vestibular schwannoma and other problems in the pontocerebellar space.

Material and Methods: Retrospective review of postoperative convalescence of 75 patients operated by translabyrinthine approach for a big vestibular schwannoma, which according to NMR imaging blocks the foramen Luschka, out of all series of 151 patients, 45 vestibular schwannoma patients operated elsewhere by suboccipital approach and 15 patients operated by minimum retrosigmoid approach for various neurootologic problems is presented. Translabyrinthine and suboccipital surgery were performed in 1996 to 2007. The shortest duration of the follow up time was one year. Minimum retrosigmoid surgery was performed in 2008 - 2009; the shortest follow up time was 6 months.

Results: Balance functions after translabyrinthine removal of big tumours (75 patients): after 2 months - mild instability 69 and moderate instability 6 patients, after 1 year mild instability when tired 18 patients. Balance functions - retractor disease after suboccipital removal of medium and big tumours (45 patients) after 1 year and longer: severe instability 28, moderate instability 11, mild instability 6, meatus not opened and residuum growing 7 patients. Balance functions after minimum retrosigmoid approach for various diseases (15 patients): balance problem after 2 months - no patient.

Conclusion: In case of vestibular schwannoma 2 cm<, when the foramen Luschka is usually blocked with a tumour, translabyrinthine approach is chosen. In the case of tumours >2 cm, if there is not any hearing category A, B, C translabyrinthine approach is chosen. In the case of tumours <1,5 cm fulfilling the criteria for possible preservation of hearing retrosigmoid approach is chosen. The group of tumours 1,5cm ≤ 2,5 cm is the group where the shift in the indication of the surgery is possible, it is based on a surgeon´s experience and preference.

Submitted : 06 October 2009 *Revised : 16 March 2010* *Accepted : 02 April 2010*

Introduction

In the second half of the 20th century new possibilities of a surgical access to the pontocerebellar angle have come into existence [1-8]. Not only new functional and displaying techniques were implemented but also transtemporal approaches using an operative microscope and a new instrumentation. The important role in this process plays anaesthesiology which is being permanently improved and technical equipment, where it is also necessary to emphasise the implementation of peroperative monitoring and videoendoscopy[2,3,9,10]. Now we may talk about the absolute decrease of mortality, less serious postoperative consequences, preservation of the facial nerve function, and in some cases even about the preservation of hearing. It is not only suboccipital craniotomy anymore. There is a place for an elective approach - the most suitable for a given patient. One thing has not changed and will never change - anatomy. The status of foramen Luschka besides others is absolutely important at intervention in the pontocerebellar angle; foramen Luschka can be free, partially or totally blocked by tumour.

In this paper is presented how the tumour size in the pontocerebellar angle - a big tumour blocking the foramen Luschka and the small one not impairing CSF circulation, influences our choice of neurotologic approaches - translabyrinthine and retrosigmoid in the treatment of vestibular schwannoma and other problems in the pontocerebellar space.

Material and Methods

The first series comprises 155 patients suffering from vestibular schwannoma, treated surgically in the years 1996-2007. Translabyrinthine approach was used in 151 cases. In 4 cases retrosigmoid approach was used. The tumour was intrameatal. In 4 cases, in 30 cases

Corresponding address:
Pr. Juraj Koval
Department of Otorhinolaryngology Head & Neck Surgery University of P.J. Safarik, Faculty of Medicine, L. Pasteur University Hospital, NP 1, 04001 Kosice, Slovakia
Phone: +421 55 640 3736; E-mail: juraj.koval@upjs.sk

the extrameatal part was up to 1.5 cm, in 46 cases the size of this part was from 1.5cm up to 2.5 cm, in 54 cases the extramental part had from 2.5 to 3.5 cm and in 21 cases the tumour was bigger than 3.5 cm.The tumours were then classified according to the space they occupied in the pontocerebellar angle and pressure impact on surroudings (Table 1). This table shows there were 34 tumours up to 1.5 cm in which did not appear any pressure changes on surrounding structures; there were no deformations of the brainstem or the cerebellum and the circulation of CSF was not affected as well - a group of small tumours. There were also 75 tumours of 2.5 cm and larger completely filling the pontocerebellar angle, they caused the pressure on the surrounding structures and frequently had a negative influence on the CSF circulation -large tumours. Finally, there was a group comprising 46 tumours from 1.5 cm up to 2.4 cm-medium size tumours which according to the nuclear magnetic resonance (NMR) image did not cover regularly all parameters of large tumours; however based on the surgical experience concerning the occurrence of adhesions and their difficult removing, it is known tumours from 2 cm often fulfil the attributes of large tumours.

The second series comprises 45 patients with vestibular schwannoma 2.5 cm and larger operated elsewhere by suboccipital approach.

The third series comprises 4 patients with vestibular schwannoma smaller than 1.5 cm operated by minimum retrosigmoid approach and 11 other patients with various other problems - epidermoid, arachnoid cyst, hemifacial spasm, trigeminal neuralgia and vertigo operated by the same approach.

All patients where retrospectively analysed: preoperative hearing, postoperative hearing, preoperative and postoperative balance functions - electronystagmography, questionnaire and nuclear magnetic resonance imaging (NMR).

Table 1. Vestibular schwanoma patients – tumour size

Vestibular schwanoma	cases
Small: to 1.5 cm	34
Medium: 1.5-2.5 cm	46
Big: 2.5 cm and more	75
Total	155

Results

The NMR images of all our patients having a big tumour, i.e. 2.5 cm and bigger showed some signs of brainstem compression and in tumours near 3cm foramen Luschka blockage as well as CSF circulation impairment were always evident.

Table 2 shows the status of hearing at the side affected by a huge tumour - 2.5 cm and more before its translabyrinthine removal. One patient had hearing category “A”, 1 patient had hearing category “B”, 13 patients had hearing category “C”, 60 patients had category “D”. All the patients lost the rest of their hearing at the affected side after the surgery.

Table 3 shows how we were able to differentiate the course of the cochlear nerve in these huge tumours. It was possible to differentiate the nerve in the internal auditory canal in all cases. At the brainstem entry zone cochlear and vestibular nerves merged and their discrimination was illusory up to 84 % of the cases. The cochlear nerve in its course on the surface of the tumour was fading away or was a part of the tumour up to 89 % of the cases.

Table 4 shows vestibular respectively cerebellar symptomotology before translabyrinthine removal of these tumours. Nine patients were asymptomatic, 11 patients showed instability, but only in darkness. Significant instability in the light was present in 13 patients. Cerebellar symptomology (ataxia, dysdiadochokinesis) was reported in 42 patients.

Table 5 presents the status of balance functions in the same group at the time of discharge from the hospital, after 2 months and after 1 year. On the 14th day after the surgery the vestibular compensation was developed in a good quality in all the patients excluding 4 of them. The patients being in the good health conditions could go home having minimal instability. On the 14th day after the surgery only 4

Table 2. Hearing in tumours 2,5 cm and bigger

Tumours 2.5 cm and bigger - hearing	cases
A ≤ 30 dB/discrimination ≤ 70%	1
B 30 – 50 dB/discrimination ≤ 50%	1
C ≤ 50 dB/discrimination ≤ 50%	13
D discrimination ≤ 50%	60
Total	75

Table 3. Good differentiation of the cochlear nerve during procedure

Good differentiation of the cochlear nerve	cases
Meatus	100%
All PC segment on tumour	11%
At brainstem entry zone	16%
Nerve merged in tumour	89%
At brainstem entry zone cochlear and vestibular nerve marge	84 %

Table 4. Vestibular and cerebellar symptomatology in tumours 2.5 cm and bigger

Vestibular and cerebellar symptomatology	cases
Asymptomatic	9
Instability in dark	11
Instability in light	13
Cerebellar symptomatology	42
Total	75

Table 5. Balance function after 2 weeks, 2 months and 1 year – tumours 2.5 cm and bigger

Balance functions after 2 weeks, 2 months and 1 year	cases
Instability after 2 weeks	71
Ataxia after 2 weeks	4
Mild instability after 2 months	69
Moderate instability after 2 months	6
Ataxia after 1 year	0
Instability when tired after 1 year	18

patients displayed ataxia, but had improved during the next week so that we could talk only about instability and the patients were able to go home without having bigger problems. Two months later 69 patients had mild instability and only 6 patients had moderate instability. One year after the operation the magnetic resonance image of all checked patients demonstrated that the quality of the cerebellum hemisphere was without traumatic changes and the vestibular compensation was well developed; one quarter of them reported moderate instability when being tired.

This paper is not dealing with the function of the facial nerve. This function was presented in our other works[11-12].

Table 6 shows balance functions - retractor disease after suboccipital removal of big tumours (45 patients) after 1 year and longer: severe instability in 28 patients, moderate instability in 11 patients, mild instability in 6 patients, meatus not opened and residuum growing in 7 patients, severe cerebellar damage (NMR image) in 19 and moderate cerebellar damage (NMR image) in 9 patients.

Table 7 shows balance functions after minimum retrosigmoid approach for small vestibular schwannoma in 4 patients and other problems (11 patients): balance problem after 2 months - no patient.

Discussion

The goal of the surgical treatment of vestibular schwannoma is its total extirpation with no or absolutely minimal mortality and minimal morbidity - good function of the facial nerve and good condition of the balance functions which have the greatest influence on a fast comeback to a normal life. It is even more important to take in an account the fact that the majority of disease-ridden are people in a working age. Our patients having tumour of 2.5 cm or bigger acknowledges the fact that in these cases is usable hearing mostly the curiosity than regularity, and only in a small number of them there is a chance to preserve hearing. At the analysis of surgical findings of this group it happened nearly in all cases that we could not reliably define cochlear and vestibular nerves; both nerves in their course were often fading away or they were a part of the tumour.

Table 6. Problems after suboccipital vestibular schwannoma removal

Retractor disease after suboccipital removal	cases
Severe cerebellar damage (NMR) and instability	19
Moderate cerebellar damage (NMR) and instability	9
Meatus not opened and residual tumor growing	7
Moderate instability, no cerebellar damage	11
Mild instability, no cerebellar damage	6
Total	45

Table 7. Minimal retrosigmoid approach group - 15 cases

Minimal retrosigmoid approach	cases
Small vestibular schwanoma ≤1.5 cm	4
Epidermoid 3 x 2 cm	1
Arachnoid cyst	2
Neurovascular conflict	3
Vestibular nerve section	5
Balance problem after 2 months	0

There are questions we are trying to answer today: Haven't we harmed our patients using translabyrinthine approach causing deafness at the operated side? Isn´t time for modifying our indication criteria for translabyrinthine surgery? Nowadays we are asking these questions even more, because we have got experience also with a minimal retrosigmoid approach by a means of which we removed a tumour and we succeeded in preserving normal hearing. Before trying to find the answers on these questions let´s think of Foramen Luschka and CSF circulation.

Figure 1 schematically depicts circulation of CSF that fills the brain ventricles, central spinal cord canal and whole subarachnoid space. The CSF is made in ependymal cells of the chorioid plexuses located in the ventricles of the brain. The ventricles and subarachnoid space are connected by means of three apertures/ openings located in the fourth ventricle - medially at the back there is foramen Magendie and laterally on both sides is foramen Luschka. Figure 2 presents an endoscopic view into the pontocerebellar cistern after the tumour has been removed by the translabyrinthine approach; topographically the foramen Luschka is located between the brainstem entries of nerves VIII and IX, i.e. in the area which is regularly being depleted by a vestibular schwannoma having size 2.5 cm or more (Figure 3). CSF is running from the ventricles into subarachnoid space via mentioned apertures and from there it is reabsorbed in the superior sagittal sinus where arachnoid granulations performing absorption are located. In the case of an obstruction of above mentioned communication apertures/openings between the brain ventricles and subarachnoid space the circulation of CSF is getting worse and it is being cumulated in the ventricles, i.e. internal hydrocephalus. Hypertension in the ventricles damages the brain tissues. Distinctive overpressure in the ventricles substantially deteriorates effect of modern anaesthesiologic techniques (hyperventilation at the level pCO_2 = 25mmHg) as well as their positive effect on the brain tissue in the meaning of depression of cerebellum, which is a fundamental requirement of non traumatic access into a pontocerebellar cistern that could be e.g. totally filled by a huge tumour simultaneously clogging foramen Luschka. It is necessary to emphasise the fact that it is not possible to compress liquid, only the brain tissue - cerebellum hemisphere can be compressed and

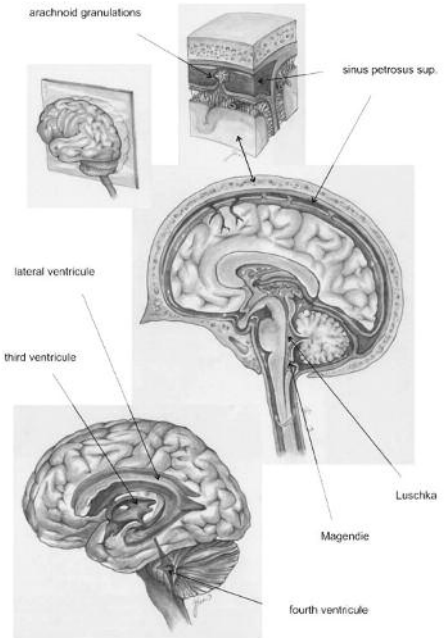

Figure 1. Production, circulation and resorption of the CSF
The CSF is produced in the chorioid plexuses in the brain ventricles which communicate with the subarachnoid space only through three openings located in the 4th ventricle: one medianne - foramen Magendie and two lateral - foramina Luschka. The CSF is resorbed in the arachnoid granulations in the superior sagittal sinus.

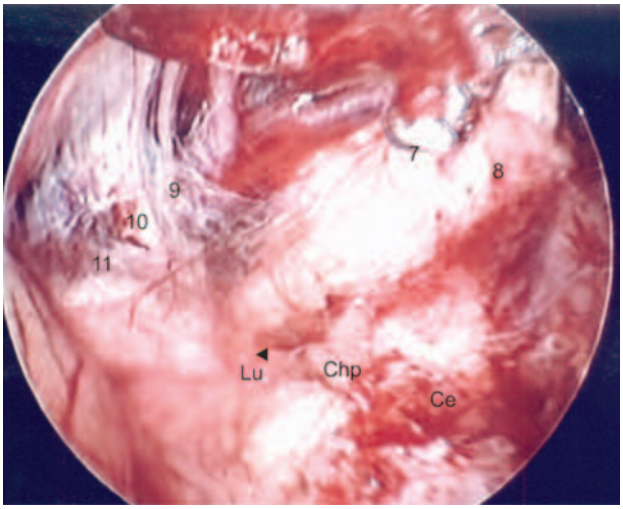

Figure 2. Translabyrinthine endoscopic view into the left pontocerebellar space after removal of meningioma of 3cm; Foramen Luschka is nicely visible.
Lu - foramen Luschka, Chp - chorioid plexus, Ce - cerebellum, 7 - facial nerve,
8 - cochleovestibular nerve, 9 - glossopharyngeal nerve, 10 - vagus nerve,
11 - accessory nerve

Figure 3. Vestibular schwannoma of 3,5 cm - left side
In such a tumour size the foramen Luscha is blocked. There are two options of removing it depending on a surgeon preference. RS arrow - posterior: retrosigmoid, suboccipital, TL arrow - lateral: translabyrinthine. Dotted arrow shows the place where the arachnoid of the pontocerebellar cistern is cut and the CSF is evacuated from the opposite foramen Luschka after debulking of the tumour - the ipsilateral foramen Luschka is still blocked with the tumour capsule. Such a manoeuvre is possible during translabyrinthine approach without touching the brain tissue.

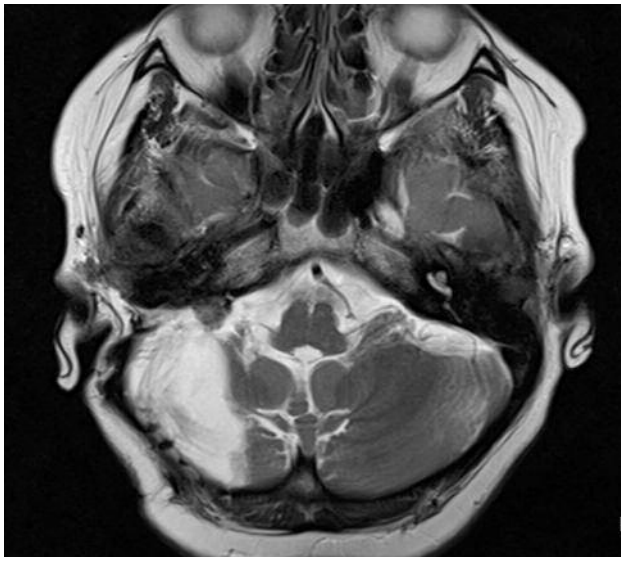

Figure 4. NMR image of "retractor disease" still present 10 years after suboccipital partial vestibular schwannoma removal - right side.

compression always causes certain trauma. The range and severity of the trauma depends on as follows: an amount of the pressure having effect on the cerebellum, time period the cerebellum is subjected to the pressure, regardful/nonregardful manipulation. Increased infratentorial pressure originates from combining two mechanisms: firstly - a huge tumour, secondly - the internal hydrocephalus caused by foramen Luschka obstruction.

We would like to pay detailed attention further to both translabyrinthine and retrosigmoid, or suboccipital procedures.

Suboccipital approach is performed in the area behind the sigmoid sinus, nowadays this term is replaced by the term retrosigmoid approach, but this surgery differs from minimally invasive neurootologic retrosigmoid approach[2,3,13,14]. Reservations of the protagonists of the posterior suboccipital approach against the lateral translabyrinthine approach could be covered by four points:[15] 1. Posterior approach gives a chance to preserve hearing while lateral translabyrinthine approach has not such a chance. 2. Use of lateral transtemporal approaches causes deafness 3. Use of suboccipital craniotomy is the best method to make available all areas of posterior cranial fossa, therefore it allows the best control of the area being operated. 4. Transtemporal lateral approaches do not allow this and are insufficient for removing large tumours.

If we accept this philosophy, there would be really left not very many indications for neurootologic surgery, e.g. small tumour causing deafness. On the other hand we saw patients (operated elsewhere), some of them are still being observed, which were subjected to extirpation of a large tumour by suboccipital craniotomy. Many patients had a long lasting ataxia, distinctively longer recovery. When we were evaluating NMR images, we often saw big changes on the hemisphere of cerebellum (retractor disease- Figure 6) or even statuses after partial resection of the cerebellum hemisphere. NMR examination often showed that the internal auditory canal had not been opened. We also observe patients with the left residuum which has grown up several years after the surgery to the same size as the original tumour was. Hearing of all these patients was examined, in all cases

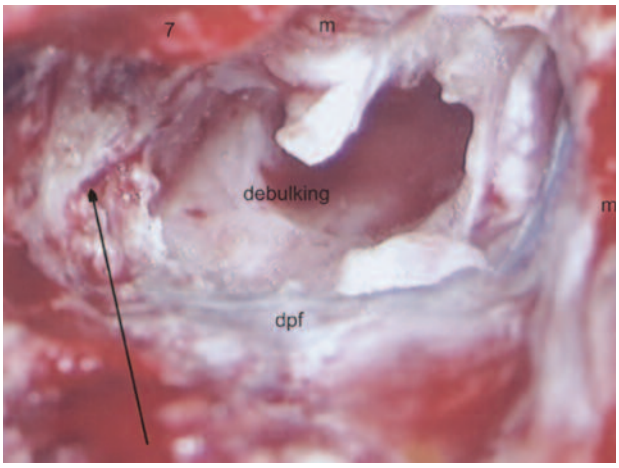

Figure 5. Translabyrinthine approach - left side
Debulking of the tumour has already been performed. We can see a very nice reduction of the tumour volume and excellent decrease of intracranial pressure without any touch on the brain tissue. The arrow shows the place for penetrating with microraspatorium into the pontocerebellar cistern for cutting the arachnoid which makes it possible to evacuate the CSF from the ventricles through the opposite foramen Luschka.

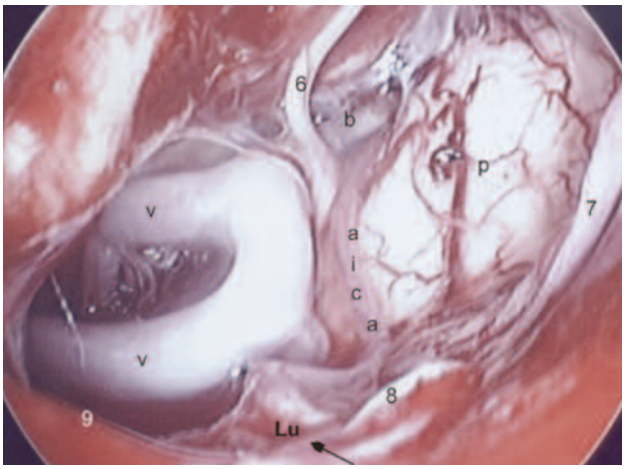

Figure 6. Endoscopic view into the left pontocerebellar angle after vestibular schwannoma removal - the same surgery as in Figure 7,8 Lu - foramen Luschka, v - vertebral artery, b - basilar artery, p - pons Varoli, 6 - abducens nerve, 7 - facial nerve, 8 - remnant of cochleovestibular nerve, 9 - glossopharyngeal nerve, aica - anterior inferior cerebellar artery, arrow shows on the foramen Luschka

deafness on the operated side was found.

In the treatment of the vestibular schwannoma we have got the biggest experience in translabyrinthine approach to tumours of any size; during last two years we have also earned experience with the minimal retrosigmoid approach to small tumours. We tried to remove them and preserve hearing.

The postoperative recovery of our patients was fast even when the large tumours were removed by translabyrinthine approach. Naturally, all our patients suffer from deafness located at the operated side. There were 4 patients we tried to preserve their hearing by applying minimum retrosigmoid approach - all 4 had a small tumour which did not somehow affect the circulation of CSF. We were successful in 2 cases.

We do not want to discuss the postoperative function of the facial nerve. Logics of anatomy is clear - the easiest way to make the facial nerve accessible from the ascent from the brainstem to the foramen stylomastoideum is the use of translabyrinthine way.

If suboccipital craniotomy is the best method then the elective approach to the treatment of vestibular schwannoma has no sense. We are confident that an elective approach is tangible and the principal for this claim is anatomy in which foramen Luschka plays the key role. Let us think about the pontocerebellar angle affected by a small or big tumour in two situations done by posterior, retrosigmoid and lateral, translabyrinthine access to it. Figure 3 shows a large tumour in the pontocerebellar angle blocking directly foramen Luschka on the left side and it is as well indirectly blocking two other openings, Magendie and opposite Luschka - they are compressed by the brain tissue, because of distinctive intraventricular overpressure. If in this situation suboccipital or retrosigmoid craniotomy is performed (indicated in Figure 3) and we open dura mater of the posterior fossa, cerebellum will be pushed into craniotomy and it is necessary to pull it away medially under the enormous intracranial pressure by a means of a retractor. Only after the cerebellum is being pulled away it is possible to touch the tumour. The compression of cerebellum even more increases infratentorial pressure untill the moment the given status is reached - CSF starts running from the pontocerebellar cistern. The cistern is totally fulfilled by the large tumour. Therefore in such conditions it is necessary to reduce the volume of the tumour - in the conditions of increased intracranial pressure being stressed by a surgical manipulation, compression of cerebellum by a retractor.

On the other hand, if we perform the translabyrinthine craniotomy and open dura mater of posterior fossa in an appropriate extent, i.e. sometimes

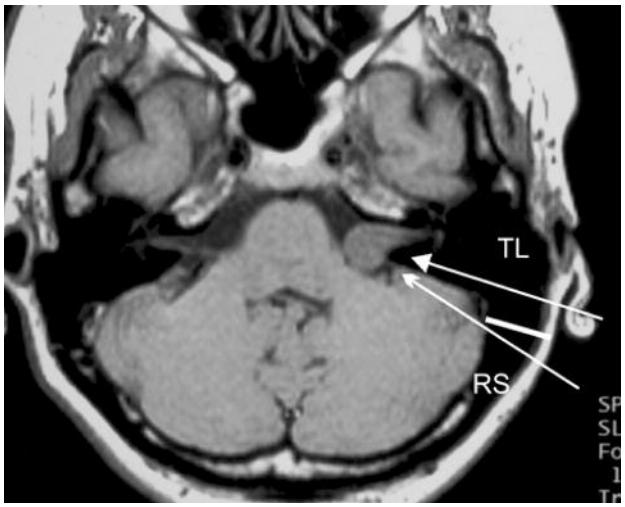

Figure 7. Small vestibular schwannoma - left side
Circulation of the CSF is good. In such a situation also the minimal retrosigmoid approach may be performed without deep compression of the cerebellum

from the internal auditory meatus up to the sigmoid sinus, the tumour penetrates into the transtemporal craniotomy and, at this time, it is for the first time the pressure in the posterior fossa is decreasing because the tumour is penetrating into the temporal bone space; it is very similar to the penetration of the cerebellum into the retrosigmoid craniotomy. Thus at the translabyrinthine approach the intracranial pressure drives the tumour directly against the surgeon and it enables him/her to perform extensive intracapsular extirpation-debulking without touching the brain tissues (Figures 7, 8).

Appropriate debulking reduces the tumour volume which causes further decrease of the pressure in the posterior fossa and this leads to gradual releasing of foramen Luschka on the opposite side (the ipsilateral foramen Luschka is still blocked by the tumour capsule), circumstances for the CSF circulation are becoming better. At this moment of the translabyrinthine surgery it is possible to get into the pontocerebellar cistern by a means of a microraspatorium as it is shown in Figure 8. This enables CSF to start running from opposite foramen Luschka, i.e. from the ventricular system. This is the key moment of the whole surgery, because the intracranial pressure is not only getting normal but it is even decreasing and cerebellum remits. Now it is possible to develope the tumour capsule by pulling or pushing it into the centre of the tumour and it is being removed step by step. Always, when it is possible, we try to avoid to touch the brain tissue.

Stiff synechie of the capsule with the brainstem in large tumours are quite often presented. They are released as the last ones, they are usually located in the area of the pontocerebellar segment of the facial nerve and, of course, in the area of foramen Luschka. The removal of the last piece of the tumour means absolute release of foramen Luschka and normalization of the CSF circulation. It is checked endoscopically at the end of the procedure (Figure 9).

Situation in removing small tumours (Figure 10) is different. In these cases the minimal retrosigmoid approach with craniotomy having the diameter 2cm is sufficient. A good anesthesiologic technique, protection of cerebellum by a dural patch, fast opening of the pontocerebellar cistern in the area of foramen Luschka enable leaking of CSF from the ventricular system and the cerebellum distinctively slackens. If a big cotonoid instead of a refractor is used, and it is placed between the pyramid posterior to the lateral mixed system nerves and the cerebellum, the sufficient space for work is created. Such an approach is minimally invasive and as well it is suitable for the section of the vestibular nerves, decompression procedures in neurovascular conflicts [5,6] and also for quite big lesions of cystic character.

It has to be said that these small tumours can be also removed through the middle fossa or extended middle fossa approach.

Even an experienced surgeon, trying not to traumatise the brain tissue may be limited of the anatomic situation in the area affected by the large tumour which is impairing the CSF circulation.

Conclusion

Nowadays, when thinking about our surgical indications for vestibular schwannoma removal, we have to state that mostly the logics of anatomy and physiology of the CSF circulation which is frequently changed by foramen Luschka blockage by a huge tumour, must be taken into account:

1. In the case of tumours larger than 2cm translabyrinthine approach is chosen.
2. In the case of tumours up to 2cm, if there is not any hearing - category A, B, C, translabyrinthine approach is chosen.
3. In the case of tumours smaller than 1,5cm fulfilling the criteria for possible preservation of hearing retrosigmoid approach is chosen. Such

an approach may be suitable also for bigger lesions of cystic character, vestibular nerve section and decompression procedures in neurovascular conflicts.

4. In those tumours may be used middle fossa approach as well.
5. The group of tumours from 1.5 cm up to 2.5 cm is the group where the shift in the indication of the surgery will be possible, based on our experience with minimum retrosigmoid approach.

The final indication of the operative procedure makes the patient himself/herself after detailed explanation of the problem and information about our possibilities and our experience with mentioned surgical approaches.

Anatomy and physiology of creation, circulation and resorption of CSF is an axiom. The tumour in the pontocerebellar angle may change it distinctively. Neurootologic techniques take in an account this fact in the meaning of elective approach the best for the patient as well as thinking about individual experience of a surgeon.

References

1. House, W., Luetje, C., Doyle, K. Acoustic tumors: diagnosis and management. Singular Publishing Group, Inc., San Diego, 1997, 359p.

2. Magnan, J., Chays, A., Lepetre, C. Pencroffi E, Locatelli C Surgical perspective of endoscopy ofthe cerebellopontinne angle. Am. J. Otol., 1994; 15:366-370.

3. Magnan, J., Chays, A., Cohen, J-M. et al. Voie retrosigmoide et endoscopie de l´angle ponto-cerebelleux: indications et resultats. JFORL, 1994; 43: 347-352.

4. Morawski K., Telishi F., Niemczyk K. A model of real time monitoring of the cochlear function during an induced local ischemia. Hearing Research 2006; 212: 117-127.

5. Niemczyk K., Dubrulle F., Vaneecloo FM, Lejeune JP., Lemaitre L, Bruzgielewicz A Vincent C. Clinical implications of acoustic neuromas growth rate in volumetric study Ann Otolaryngol Chir. Cervicofac. 2002; 119:259-63.

6. Niemczyk K., Vaneecloo FM., Lemaitre L. Lejeune SP, Lemaitre L, Skarzynski H, Vincent C, Dubrulle F, The Growth of Acoustic Neuromas in Volumetric Radiological Assessment. American Journal of Otology 1999; 20:244-248.

7. Niemczyk K., Vaneecloo FM., Lecomte MH. Legeune JP, Lemaitre L, Skarzynki H, Dubrulle F, Vincent C. Correlation between Ki-67 index and some clinical aspects of acoustic neuromas (vestibular schwannomas). Otolaryngol Head Neck Surg. 2000; 123: 779-83.

8. Sterkers, JM., Sterkers, O. Le neurinome de l´acoustique - La neurofibromatose de Type II. Les monographies du cca Wagram, Paris, 1997, 64p.

9. Morawski K., Niemczyk K., Bohorquez J., Marchel A, Delgado RE, Ozdamar O, Telischi FF Intraoperative monitoring of hearing during cerebello-pontine angle tumor surgery using transtympanal electrocochleography. Otol Neurotol. 2007; 28:541-545.

10. Sastry A, Munzer Al-Waa A, Zaman S. Magnetic resonance imaging for acoustic neuromas Mediterr. J. Otol. 2007; 3: 117-119.

11. Koval, J., Sulla I., Krempaská, S., et al. Standpoint of surgeon on preservation of facial nerve function in removing of vestibular schwannoma by translabyrinthine approach. Otorinolaryng. Foniatr./ Prague/ 2006; 55:199-205.

12. Kaliarik, L., Krempaská , S., Koval, J. Standpoint of the monitoring specialist on preservation of facial nerve function in removing of vestibular schwannoma by translabyrinthine approach. Otorinolaryng. Foniatr. /Prague/ 2006; 55:206-212.

13. Koval, J., Krempaská, S., Kaliarik, L. Minimal retrosigmoid approach with applied endoscopy. Otorinolaryng. Foniatr. /Prague/ 2009; 58:8-14.

14. Magnan, J. Deveze A, Myazaki H, Berni Canani F Cerebellopontine angle surgery by the retrosigmoid approach: Our experience in the elderly patients. Mediterr. J. Otol. 2005; 1:1-7.

15. Jackler, R., Brackmann, D. Neurotology. Mosby, St. Louis, 1994, 1464p.