PREOPERATIVE PREDICTIVE FACTORS FOR HEARING PRESERVATION IN VESTIBULAR SCHWANNOMA SURGERY

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ABSTRACT

Objectivses: To evaluate the various predictive factors for postoperative hearing preservation in the surgical management of Vestibular Schwannoma.

Study Design: Retrospective chart review

Methods: Out of 792 cases operated for Vestibular Schwannoma between , 107 were the candidate for hearing preservation surgery. These patients were divided into Group I (hearing preserved) & Group II (hearing not preserved) and both of these groups were evaluated for age, sex, pure tone average (PTA), sound discrimination score (SDS), tumor size, ABR parameters. Corrected χ^2 test and corrected *t* test were used for statistical analysis. Multiple regression analysis was further done to evaluate the independent predictive factor either alone or in combination. Results were evaluated by using Modified Sanna classification and American academy guidelines.

Results: Pre operative pure tone average and tumor size were the two predictive factors in our study. Pearson correlation test showed that there was no multicollinearity between the factors. On multiple regression analysis by backward elimination of non significant factor/s, we found that tumor size is the independent predictive for post operative hearing. According to Modified Sanna Classification postoperative hearing was preserved in 11.2% of patients which is equivalent to Class A of American academy guidelines.

Conclusion: In our series pre operative PTA and tumor size were found out to be predictors of postoperative hearing levels.

Key Words: Hearing preservation, predictive factors, vestibular schwannoma, modified sanna's classification.

INTRODUCTION

Technical refinements in radiological investigations and heightened awareness of early symptoms and signs have made it possible to diagnose a case of vestibular schwannoma (VS) while the tumour is small and hearing is normal or near normal. This fact has come across the surgeon with a new challenge in managing VS: preservation of hearing. Many reports have been published in the literature regarding the results of hearing preservation surgery and various preoperative and intraoperative factors for the prediction of the final outcome have been identified. Based on these reports a consensus rapidly appeared in the literature in recognition of two factors capable of predicting hearing preservation: preoperative hearing level and tumour size. Several other precise predictive factors such as hearing loss at 500Hz, widening of internal auditory meatus, adhesiveness of the tumour, latencies of different waves in auditory brainstem response (ABR), presence of transient evoked otoacoustic emissions(TEAOEs) and short duration of hearing loss have been studied but their role in predicting the outcome is still controversial. Most of the series have done univariate analysis of the data, looking at each factor separately but Ferber-Viart[1] et al, Nadol[2] et al & Rastogi[3] et al and have used regression analysis (logistic or multiple) to determine the best predictors of hearing preservation either alone or in combination. A comparison of the various predictive factors reported in the literature are summarised in table I.

Reported rates of hearing preservation vary from 10% to 77% in the literature[1-16,22-29]. This wide variation in the results is due to the fact that some authors consider any measurable hearing as the preserved hearing while others consider serviceable hearing as preserved hearing. Comparison in between these reports is also difficult due to the application of diverse hearing preservation guidelines among the surgeons and speckled criterion for suitability of a patient to be a candidate for hearing preservation surgery[16].

Intra-operative neuro-physiologic monitoring of cochlear nerve function has increased the likelihood of hearing preservation, actual preservation of 'useful' hearing level still remains an elusive goal.

In the present study, we retrospectively evaluated following variables, age, sex, preoperative pure tone average (PTA), speech discrimination score (SDS), ABR traces and tumor size in respect to the post operative PTA to validate the predictive factors already reported in the literature and to determine which of these variable, either alone or in combination are best predictors of hearing preservation.

MATERIAL AND METHODS

792 patients of VS were operated at Gruppo Otologico, Piacenza – Rome, between April1987 to July 2002 out of which 107 were selected as the suitable candidates for a hearing preservation surgery. Our criteria to select a patient for hearing preservation are: mean PTA ≤ 30dB, SDS ≥ 70% and age <65 yrs. These norms were relaxed as dictated by the profession of the patient, hearing in contra lateral ear and also patient's own will. In addition to the standard physical, neurological and otolaryngologic examination, preoperative test included pure-tone air and bone conduction audiometery, speech audiometery, ABR, computed tomography(CT) and magnetic resonance imaging(MRI) with gadolinium. All the patients were operated upon by the senior author(MS) using either Extended Middle Fossa (EMF) and Retrosigmoid (RS) approach. In the last patients RS was combined with the Retrolabyrinthine exposure of the mastoid in order to reduce the risk of post-operative rhinoliquorrea. The operative techniques are described else where[17]. We use EMF approach for the tumours reaching up to the fundus and maximum until < 0.5 cm in the extrameatal extension. Larger tumours (with maximum diameter of 1.5 in the cerebello-pontine angle CPA)) and the tumours not reaching up to the fundus were operated by using RS.

Intra operative monitoring:

Intraoperative facial nerve monitoring was done in all the cases using EMG system (NIM II, *Xomed, Jacksonville Florida*). Since 1998 we have started intraoperative cochlear nerve monitoring by recording Fast ABR and cochlear nerve action potential (CNAP) by means of MK 12 (*Amplaid, Milan*). With the digital filters introduced by Møller[18], it is possible to record the ABR traces in less than 5 second. For the intraoperative cochlear nerve monitoring we apply Fast ABR until the dura is opened and there after we combine it with CNAP which is measured by placing a silver-plaited electrode with a cottonoid close to the cochlear nerve.

Study Parameters and Statistical Analysis:

Retrospective analysis of the data obtained from computer data base was performed. Patients were divided into Group I (hearing preserved) & Group II (hearing not preserved) for the purpose of comparing the various factors in between the groups. Preoperative hearing data including four-frequency mean PTA(500; 1,000; 2,000 & 4,000 Hz), SDS and tumor size in cm. (diameter of the largest extra meatal portion of the tumor as evident on axial MRI)[19] were available of all the subjects. Pre-operative ABR records of 104 patients were available which were evaluated for the morphology and the latencies of wave I & V. ABR morphology was marked as good if the waves I, III & V were present and poor if any of these waves was not present. Difference in inter aural latencies of wave I & V (IT I V) and difference in intra aural latencies of wave 5 (ILD 5) were calculated. IT I V < 0.3 ms and ILD 5 < 0.2 ms were considered as normal[4]. Post operative PTA and SDS were available in all the patients at 1 month follow up. Postoperative hearing results were evaluated by using Modified Sanna's Classification (MSC)[20] and American Academy of Otolaryngology guidelines (AAO-HNS)[21].

Univariate statistical analysis was performed by using corrected χ^2 test for nominal categorical variables and corrected unpaired *t* test for ordered categorical variables to determine the significance of individual predictive factor for hearing preservation in group I & II. *P* value of <0.05 was considered as statistically significant. In terms of variable to variable interaction, the data was analyzed for multicollinearity and a correlation matrix was created using Pearson *r* correlation test. None of the value in the correlation matrix exceed 0.75, and the model found no multicollinearity. Thereafter logistic regression analysis was done in backward stepwise manner to identify the independent predictors for post operative hearing status. Analysis was performed by using the statistical software package Graph Pad In Stat for windows (*Graph pad In Stat Inc., San diego, CA, USA*)

RESULTS

There were 59 males and 48 females in the study. The mean age was 44.5 ± 1.59 yrs with a range from 15 yrs – 64 yrs. Mean pre operative PTA and speech discrimination score were 26.6 ± 2.11 dB and 96.8 ± 0.98 % respectively. Details of all the patients were summarised in table II.

Hearing preservation:

Hearing preservation results were evaluated by using MSC & AAO-HNS guidelines (Table III) (20). Majority of the patients belonged to Class A preoperatively i.e. 41.1% & 65.4% respectively. According to MSC, Class A & B hearing was preserved in 12 patients(11.2%) and 13 patients (12.1%)maintained their preoperative class. Hearing improvement was noticed in 1 patient. The details of MSC are summarised in table III.

According to AAO-HNS guidelines, Class A (equivalent to class A & B of MSC) hearing was preserved in 12 patients (11.2%) and 18 patients (16.8%) maintained their preoperative class. The details of AAO-HNS are summarised in table IV.

Predictive Factors

Comparative details of the group I & II are summarised in table V.

Age, Sex, Side and Surgical Approach:

None of these factors was found statistically significant between group I & II.

PTA & SDS:

Preoperative mean PTA of Group I & II were 23.44 ± 10.11 and 29.17 ± 12.71 respectively, This difference was statistically significant ($P < 0.05$, unpaired *t*-test with welch correction). Speech discrimination score was not found to be statistically significant in between the groups ($P > 0.05$, unpaired *t*-test with welch correction). Table V.

ABR morphology:

ABR traces of 104 patients were present, 42 belonged to Group I and 62 to Group II. The results are summarised in table VI. The comparison in between the groups was not statistically significant($P > 0.05$, corrected χ^2 test)

ABR latencies:

Inter-aural difference of the latencies of wave I & V(IT I V) was available of 104 patients. Forty two patients were belonged to Group I and 62 belonged to Group II. The results were summarised in table VII. The comparison in between the groups was not statistically significant ($P > 0.05$, corrected χ^2 test).

Intra-aural difference of the latency of wave 5 (ILD 5) were available of 104 patients. The results are summarised in table VII. The comparision in between the groups was not statistically significant ($P > 0.05$, corrected χ^2 test).

SIZE:

Tumour size was available in all the patients which is categorically summarised in table VIII. The statistical analysis was done using the corrected χ^2 test and *P* value was statistically significant (< 0.05).

Correlation matrix between the factors:

There was no relation ship seen in between preoperative PTA and size, which shows that the model which we have prepared does not have the problem of multicollinearity table IX.

Multiple regression analysis:

Multiple regression analysis was used to quantify the degree of association between the post operative PTA and pre operative PTA & tumor size. The results are shown in table X. The best fitting multiple regression model, selected by backward elimination, identified tumor size as an independent predictor of post operative hearing status. However pre operative PTA was significant factor also but not an independent predictor, this can be explained by the bias caused by the strict selection criteria of low preoperative PTA. Correlation between post operative PTA and tumor size is given in Figure 1. From this plot it is evident that postoperative PTA is correlated with tumor size (r = 0.213, p = 0.016). Post operative PTA(y) can be calculated from tumor size (x) according to the following equation: y = 73.0 +1.50x.

DISCUSSION

During the last few decades remarkable advances in the diagnostic and surgical management of VS have lead us to achieve low mortality and anatomic preservation of facial nerve in most of the cases and it has now become a rule rather than an exception. Intraoperative neurophysiologic monitoring for cochlear nerve function is a further addition in the surgeon's

armamentarium to refine the technique and results of hearing preservation in VS management.

Prognostic value of preoperative audiometric variables were evaluated by many authors and vary widely. Fisher, Nadol, Cohen, Kalmon, Rastogi, Robiennet, Slattery, Ferber-Viart and Brackmann have reported that low preoperative PTA is significant in hearing preservation but Dornhoffer, Mangham, Shelton and Josey have reported that this factor is not significant in hearing preservation. In our series we have found out that pre operative PTA levels are statistically significant in hearing preservation.

In the present series tumor size was negatively correlated with the hearing preservation which has been mentioned in the literature by Robinette, Dornhoffer, Kalmon, Cohen, Nadol, Fischer, Mangham, Kemink, Shelton how ever Slattery and Brackmann have not found out any statistically significant correlation. Nadol et al used logistic regression analysis to study prognostic factors related to hearing preservation. They reported that tumour size, the preoperative monosyllabic word recognition score and gender were significantly related to postoperative outcome. Glasscock in 1993 reported the association of normal ABR with the post operative PTA but in our study we could not establish any statistically significant correlations in between ABR and postoperative hearing status. Various factors reported by several authors in the literature are summarised in table I. Some other factors which are reported to be predictive of post operative hearing level in the literature such as widening of internal auditory meatus, presence of TEOAE and adhesion between the tumour and cochlear nerve were not evaluated by us.

Using multiple regression analysis we were able to formulate a model to determine expected mean post operative PTA by the size of the tumour which is shown in table X. This model explains 5.83% of the variance in the post operative PTA. Which indicates that it is not a very representative model but yes it is statistically significant. If one considers that this coloration

is still present in a population which is already highly selected, and one of the most important criteria to select these patients is tumor size, the actual significance of this value is augmented.

Ferber –Viart et al has also reported a similar type of model which explains the expected mean post operative PTA by the mean pre operative PTA. This model explains 19.3 % variance in the mean post operative PTA which again does not satisfy the patient's need. This analysis lead us to the conclusion that with the present known predictive factors we are not able to formulate a perfect predictive model with the help of which we could explain most of the variance. We need to look for other intrinsic or extrinsic factors in determining hearing preservation outcome. For example, tumour biology and its relationship with the surrounding structure, the effect of the tumour on the vascular supply to the sensory end organs, duration and extent of drilling, and several other factors may also play a role. At present, their contribution remains indeterminate.

CONCLUSIONS

In the analysis of our cases, age, sex, SDS are not parameters that have statistical significance as predictive factors for hearing preservation in vestibular schwannoma surgery. We have also analyzed the pre-operative ABR as two separated parameters (IT I-V and ILD 5) and none has statistical significance as pre-operative predictive factor as well.

Instead of our reports clearly indicate the value of preoperative PTA and tumor size in predicting the postoperative hearing levels in vestibular schwannoma surgery. On analysing the results by using the multiple regression analysis we were able to formulate a model which clearly states that tumor size is the independent predictive factor for postoperative hearing levels in the patients operated on for vestibular schwannoma even though our cases were a highly selected group as far as size is concerned.

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Table I showing the various predictive factors mentioned in the literature by several authors.

Author	Year	Approach	PTA/SDS	ABR	ENG	OAE	AGE	SIZE	ORIGIN
Rohit et al	2003	RS/MF	+	-	0	0	-	+	0
Brackmann et al	2000	MF	+	+	-	-	-	-	+
Ferber-Viart et al	2000	MF	+	+	0	-	0	0	0
Slattery et al	1997	MF	+	+	+	0	0	-	+
Robinette et al	1997	RS	+	+	0	0	0	+	0
Dornhoffer et al	1995	MF	-	+	-	0	0	+	0
Rastogi et al	1995	RS	+	0	0	0	0	-	0
Kalmon et al	1995	RS	+	-	0	0	0	+	0
Cohen et al	1993	RS	+	0	0	0	-	+	+
Glasscock et al	1993	RS/MF	0	+	0	0	0	0	0
Nadol et al	1992	RS	+	-	0	0	0	+	0
Fischer et al	1992	RS	+	-	0	0	-	+	0
Mangham et al	1992	RS	-	0	0	0	0	+	0
Kemink et al	1990	RS	0	-	0	0	0	+	0
Shelton et al	1989	MF	-	+	+	0	0	+	+
Josey et al	1988	RS/MF	-	+	0	0	0	0	0

PTA/SDS: pure tone average, ABR: auditory brainstem responses, ENG: electronystagmography, OAE: otoacoustic emission, RS: retrosigmoid approach, MF: middle fossa, +: significant factor, -: not significant factor, 0: factor not considered.

Table II showing the basic profile of the patients (n = 107)

	MEAN ± S.D.	RANGE
1. AGE	44.5 ± 1.59	15 – 64
2. PRE OPERATIVE		
PTA	26.6 ± 2.11	10- 65
SDS	96.8 ± .98	60 – 100
3. SURG. APPROACH		
M.F.	59	
R.S.	48	
4. SEX		
MALE	59	
FEMALE	48	

PTA pure tone average, SDS speech discrimination score, MF middle fossa, RS retrosigmoid

S.D. standard deviation.

Table III showing pre and postoperative hearing levels according to modified Sanna's classification (n = 107).

		PREOPERATIVE CLASS							
		A	B	C	D	E	F	TOTAL	%
POST OPERATIVE									
CLASS	A	01	-	-	-	-	-	01	0.9
	B	08	03	-	-	-	-	11	10.3
	C	11	08	09	-	-	-	28	26.2
	D	02	01	05	-	-	-	08	07.5
	E	02	02	03	-	-	-	07	06.5
	F	20	12	20	-	-	-	52	48.7
TOTAL		44	26	37	-	-	-		
%		41.1	24.3	34.6					

A-PTA: 0- 20 dB, SDS >80%; B- PTA: 21- 30, SDS 79 -70; C- PTA: 31-40 dB, SDS 69-60, D- PTA: 41-60, SDS 59-50, E- PTA: 61-80 , SDS 49-40, F-PTA: 81 onwards, SDS 39-0.

Table IV showing pre & postoperative hearing class according to American academy classification (n = 107)

		PREOPERATIVE CLASS					
		A	B	C	D	TOTAL	%
POST OPERATIVE CLASS	A	12	-	-	-	12	11.2
	B	17	04	01	-	22	20.5
	C	05	08	02	-	15	14.0
	D	36	20	02	-	58	54.2
TOTAL		70	32	05	-		
%		65.4	29.9	4.7			

A- PTA≤ 30dB, SDS≥ 70%, B PTA: 30 -50, SDS ≥ 50%, C-PTA: >50 dB, SDS≥ 50%, D-PTA any level, SDS<50%.

Table V showing comparative analysis of the both groups (n = 107)

	GROUP I (n = 43)	GROUP II (n = 64)	*p* value
Age(yrs)			
Mean ± s.d.	43.02 ± 10.91	45.45 ± 10.78	0.26 corrected unpaired *t* test
Sex			
M : F	25 : 18	34 : 30	0.75 corrected χ^2 test
Audiometery			
Mean PTA(dB) ± s.d.	23.44 ± 10.11	29.17 ± 12.71	0.01 corrected unpaired *t* test
Mean SDS(%) ± s.d.	98.60 ± 6.39	95.94 ± 12.44	0.15 corrected unpaired *t* test
Approach			
MF : RS	26 : 17	33 : 31	0.48 corrected χ^2 test

s.d.: standard deviation, M: male, F: female, MF: middle fossa, RS: retrosigmoid.

Table VI showing the results of ABR morphology (n = 104) in group I & group II.

	GROUP I (n=42)	GROUP II(n=62)
GOOD	32(76.19%)	40(64.51%)
POOR	10(23.81%)	22(35.49%)

p value of the table - 0.3 (χ^2corrected)

Table VII showing the comparison of latencies of waves seen on ABR traces. n = 104

	GROUP I (n=42)	GROUP II(n=62)
IT I V		
Normal	15(35.7%)	16(25.8%)
Abnormal	27(64.3%)	46(74.2%)
	p value = 0.4 (χ^2corrected)	
ILD 5		
Normal	20(47.6%)	18(29.1%)
Abnormal	22(52.4%)	44(70.9%)
	p value = 0.08 (χ^2corrected)	

IT I V: inter-aural difference in the latency of wave I & V, ILD 5: intra-aural difference in latencies of wave V.

Table VIII showing the comparative analysis of group I & group II in respect to the tumor size.

	GROUP I(n = 43)	GROUP II(n = 64)
I.C.	20(46.5%)	27(42.1%)
S	21(48.8%)	23(35.9%)
M	02(3.6%)	14(22%)
	P value = 0.04 (χ^2corrected)	

I.C.: intra canalicular, S: small (≤10 mm extrameatal) M: medium (>11mm ≤ 20mm),

Table IX showing details of Pearson correlation analysis.

Factors	*c.c.*	r^2	*p* value
Post PTA & Pre PTA	.2040	0.04163	0.0350
Post PTA & Size	.2319	0.05377	0.0163
Pre PTA & Size	.0887	0.0079	0.3631

c.c.: correlation coefficient, PTA: pure tone averages.

Table X: showing Multiple Regression Model: Postoperative PTA vs Preoperative PTA & tumor size

Variables	T-value	*p*-value
Pre PTA	2.31	0.023
Size	2.28	0.024

PTA: pure tone averages.

Table XI showing the details of hearing preservation rates reported in the literature according to AAO-HNS. Class A of the table corresponds to the Class A & B of MSC which we consider the hearing preservation.

Author's name	No. of patients	Surgical approach	Class (%) A	Class (%) A&B
Rohit et al, 2003	107	RS&MF	11.2	37.4
Feber-Viart et al.,2002	107	MF	22.4	43.9
Moriyama et al., 2002	30	RS&MF	23.3	70
Staecker, et al., 2000	30	RS&MF	37.0	50
Holsinger et al.,2000	47	RS&MF	26.0	43
Brackmann et al.,2000	333	MF	33.0	61
Samii et al.,1997	140	RS	19.0	40
Arriaga et al., 1997	60	RS&MF	38.0	61
Post et al., 1995	46	RS	0.4	33
Dornhoffer et al.,1995	93	MF	-	58
Haines et al.,1993	12	RS&MF	58.0	75
Glasscock et al.,1993	136	RS&MF	12.5	27
Fischer et al., 1992	99	RS	10.0	16
Kemnik et al., 1990	20	RS	35.0	50
Koos et al., 1985	115	RS	-	78

RS : retrosigmoid, MF : middle fossa, - : not mentioned in the paper.

LIST OF LEGEND:

- Figure 1: Correlation between postoperative PTA and tumor size. In the equation y = postoperative PTA and x = tumor size. POST_PTA(in dB) – postoperative PTA; SIZE in mm.