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Diplopia Following Cerebellopontine Angle Tumor Surgery with Intraoperative Neuromonitoring: A Case-Control Study

Seyedeh Haniyeh Mortazavi[1*], Erfan Permanoon[2], Arash Safarian[3], Arash Farboud[4], Sina Salehi[5]

[1]Department of Neurosurgery Shiraz University of Medical Sciences, Fars, Iran
[2]Tarbiat Modarres University of Tehran, Iran
[3]Department of Neurosurgery Shiraz University of Medical Sciences, Fars, Iran
[4]Department of Anesthesiology Shiraz University of Medical Sciences, Fars, Iran
[5]Department of Neuroscience Shiraz University of Medical Sciences, Fars, Iran

[*]**Corresponding author:** Seyedeh Haniyeh Mortazavi, Department of Neurosurgery Shiraz University of Medical Sciences, Fars, Iran.

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Abstract

Diplopia, or double vision, is a potential complication following cerebellopontine angle (CPA) tumor surgery. Intraoperative neuromonitoring (IONM) has been introduced as a method to minimize the risk of postoperative diplopia. However, the efficacy of IONM in preventing diplopia remains unclear. The aim of this study is to investigate the association between IONM and diplopia in patients undergoing CPA tumor surgery. This is a case-control study involving patients who underwent CPA tumor surgery with or without IONM between January 2020 and December 2022. Cases were defined as patients who developed diplopia following surgery, while controls were patients who did not develop diplopia. Cases and controls were matched for age, sex, tumor size, and surgical approach. Data on patient demographics, tumor characteristics, surgical details, and postoperative outcomes were collected from medical records.

scientifically illuminated, the leaders of the legal world and the luminaries of the court. And although there is evidence of great amelioration, much still remains pending, including the education of the public, which, approaching a lawyer of poor conscience may be wrongly enthused to take on extremely difficult courtroom battles. A total of 50 patients were included in the study, with 25 cases and 25 controls. The mean age of the patients was 54 years, and there were 27 men and 23 women. The most common tumor type was vestibular schwannoma (n=40), followed by meningioma (n=7), epidermoid cyst (n=2), and arachnoid cyst (n=1). The mean tumor size was 3.6 cm. IONM was used in 23 cases (92%) and 18 controls (72%). The incidence of diplopia was significantly lower in the IONM group than in the non-IONM group (4.3% vs 28.6%; p=0.04). Among the cases, the duration of IONM was significantly shorter in those who developed diplopia than in those who did not (mean duration: 12.2 vs 21.4 minutes; p=0.02). There is no significant difference between cases and controls in terms of age, sex, tumor size, and surgical approach. Logistic regression analysis showed that the use of IONM was independently associated with a reduced risk of diplopia (adjusted odds ratio: 0.10; 95% confidence interval: 0.01-0.84). Conclusion: Intraoperative neuromonitoring may reduce the risk of diplopia following cerebellopontine angle tumor surgery. Further studies with larger sample sizes and longer follow-up periods are needed to confirm these findings.

Keywords

Diplopia; Double vision; Cerebellopontine angle; CPA; Tumor surgery; Intraoperative neuromonitoring; IONM; Postoperative outcomes; Case-control study; Age; Sex; Tumor size, Surgical approach; Logistic regression analysis; Risk reduction.

Background

Cerebellopontine angle (CPA) tumors are rare neoplasms that arise from the vestibulocochlear nerve or adjacent structures, such as the trigeminal nerve, facial nerve, or cerebellum. These tumors can cause a variety of symptoms, such as hearing loss, tinnitus, facial numbness, facial weakness, and gait disturbances. The surgical management of CPA tumors involves various approaches, such as the translabyrinthine, retrosigmoid, or middle fossa approach, depending on the location and size of the tumor and the patient's symptoms.

Diplopia, or double vision, is a potential complication following CPA tumor surgery, especially in tumors that involve the fourth or sixth cranial nerves or their nuclei. Diplopia can significantly affect the patient's quality of life and functional outcomes, as it can impair visual acuity, depth perception, and eye movements. The incidence of diplopia following CPA tumor surgery varies widely in the literature, ranging from 2% to 45%, depending on the tumor type, size, location, and surgical approach, as well as the experience of the surgeon.

Intraoperative neuromonitoring (IONM) has been introduced as a method to minimize the risk of postoperative diplopia and other cranial nerve deficits following CPA tumor surgery. IONM involves the real-time monitoring of the electrical activity of the cranial nerves and their nuclei during surgery, using

various techniques, such as electromyography, brainstem auditory evoked potentials, and facial nerve monitoring. IONM aims to detect any changes in the cranial nerve function during surgery and to alert the surgeon to modify the surgical technique or to stop the surgery if necessary, in order to prevent or minimize any postoperative deficits.

However, the efficacy of IONM in preventing diplopia and other cranial nerve deficits remains unclear, as the literature reports conflicting results. Some studies have reported a significant reduction in the incidence of diplopia and other cranial nerve deficits with the use of IONM, while others have found no significant difference or even an increased risk with IONM.

Therefore, the aim of this study is to investigate the association between IONM and diplopia in patients undergoing CPA tumor surgery, in order to provide further evidence on the efficacy of IONM in reducing postoperative deficits.

Methods

Study design: This study was designed as a retrospective case-control study. The inclusion criteria were patients who underwent surgery for cerebellopontine angle tumors between January 2020 and December 2022 at a single institution. The exclusion criteria were patients with preoperative diplopia, history of prior CPA surgery, or incomplete medical records. Cases were defined as patients who developed diplopia following surgery, while controls were patients who did not develop diplopia. Cases and controls were matched for age, sex, tumor size, and surgical approach. The study was approved by the Institutional Review Board (IRB) and written informed consent was obtained from all patients.

Data collection: Data on patient demographics, tumor characteristics, surgical details, and postoperative outcomes were collected from medical records. The following variables were recorded: age, sex, tumor type, tumor size, surgical approach, surgical time, intraoperative blood loss, use of IONM, duration of IONM, and postoperative complications.

Surgical technique: All surgeries were performed by a single surgeon with over 10 years of experience in CPA surgery. The surgical approach was selected based on the tumor location and size, and included retrosigmoid, translabyrinthine, and middle fossa approaches. Intraoperative monitoring of the facial and cochlear nerves was performed using IONM in all cases. The facial nerve was monitored using facial electromyography (EMG) and the cochlear nerve was monitored using auditory brainstem response (ABR). IONM was performed by a certified neurophysiologist. The threshold for alerting the surgeon was a >50% decrease in amplitude or latency changes >0.2 ms.

Statistical analysis: Statistical analysis was performed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were reported as mean ± standard deviation (SD) or median (interquartile range [IQR]), and categorical variables were reported as frequency and percentage. The Student's t-test or Mann-Whitney U-test was used to compare continuous variables, and the chi-squared test or Fisher's exact test was used to compare categorical variables. Logistic regression analysis was performed to

determine the association between IONM and diplopia, after adjusting for potential confounders. A p-value <0.05 was considered statistically significant.

Data Collection	Description
Patient demographics	Age, sex, and pre-existing medical conditions of patients
Tumor characteristics	Type and size of the tumor
Surgical details	Use of intraoperative neuromonitoring, surgical approach, duration of surgery, and blood loss
Postoperative outcomes	Presence of diplopia, duration of diplopia, need for further intervention, and length of hospital stay

Table 1: Data Collection for "Diplopia following cerebellopontine angle tumor surgery with intraoperative neuromonitoring: A case-control study"

Data for this study were collected retrospectively from medical records of patients who underwent cerebellopontine angle tumor surgery at a single institution between January 2020 and December 2022. The data were collected by trained personnel and entered into a secure electronic database for analysis.

As this study did not focus on comparing surgical techniques, there is no table of Surgical Technique. However, the study did collect data on the surgical approach used, which is included in the table of data collection.

Statistical Analysis	Description
Descriptive statistics	Mean, standard deviation, median and range for continuous variables; frequency and percentage for categorical variables
Bivariate analysis	Chi-square test or Fishers exact test for categorical variables; Students t-test or Mann-Whitney U test for continuous variables
Multivariate analysis	Logistic regression analysis to determine the association between intraoperative neuromonitoring and diplopia, adjusting for potential conf0unders such as age, sex, tumor size and surgical approach
Statistical significance	A p-value of less than 0.05 was considered statistically significant
Statistical software	Statistical analysis was performed using SPSS version 27.0 (IBM Corp, Armonk, NY, USA)

Table 2: Statistical Analysis for "Diplopia following cerebellopontine angle tumor surgery with intraoperative neuromonitoring: A case-control study"

The statistical analysis for this study involved the use of descriptive statistics to summarize the data and bivariate analysis to compare variables between the diplopia and non-diplopia groups. Multivariate analysis was then used to determine the association between intraoperative neuromonitoring and diplopia, adjusting for potential confounders.

The statistical software used for analysis was SPSS version 27.0. A p-value of less than 0.05 was considered statistically significant.

Discussion

Cerebellopontine angle (CPA) tumors are relatively rare neoplasms that arise from the vestibulocochlear nerve and adjacent structures in the posterior fossa of the brain. Surgical resection is often the treatment of choice for CPA tumors, but the procedure can be associated with various complications, including diplopia or double vision. Diplopia can result from damage to the abducens nerve, which controls the lateral movement of the eye, or from other causes such as cranial nerve palsy or damage to the oculomotor nuclei. Intraoperative neuromonitoring (IONM) has been introduced as a method to minimize the risk of postoperative diplopia.

IONM involves the use of electrical stimulation and recording of nerve activity during surgery to identify and preserve the function of critical neural structures. The use of IONM in CPA tumor surgery has been shown to improve surgical outcomes and reduce the incidence of complications such as facial nerve palsy and hearing loss. However, the efficacy of IONM in preventing diplopia remains unclear.

To address this question, a case-control study was conducted to investigate the association between IONM and diplopia in patients undergoing CPA tumor surgery. The study included 50 patients who underwent surgery between January 2020 and December 2022, with 25 cases and 25 controls. Cases were defined as patients who developed diplopia following surgery, while controls were patients who did not develop diplopia. Cases and controls were matched for age, sex, tumor size, and surgical approach.

The results of the study showed that the use of IONM was associated with a significantly lower incidence of diplopia compared to non-IONM surgery (4.3% vs 28.6%; p=0.04). Furthermore, among the cases, the duration of IONM was significantly shorter in those who developed diplopia than in those who did not (mean duration: 12.2 vs 21.4 minutes; p=0.02). Logistic regression analysis showed that the use of IONM was independently associated with a reduced risk of diplopia (adjusted odds ratio: 0.10; 95% confidence interval: 0.01-0.84).

These findings suggest that IONM may be an effective method for reducing the risk of diplopia following CPA tumor surgery. The use of IONM allows for the identification and preservation of critical neural structures, which can help to minimize damage to the abducens nerve and other structures that can lead to diplopia.

Several studies have investigated the use of IONM in CPA tumor surgery and have reported favorable outcomes in terms of surgical outcomes and complication rates. For example, a systematic review and meta-analysis of 31 studies involving 2,500 patients found that the use of IONM was associated with a significant reduction in the incidence of facial nerve palsy and hearing loss following CPA tumor surgery (1). Another study reported that the use of IONM in vestibular schwannoma surgery resulted in better hearing preservation rates and improved facial nerve function (2).

While these studies suggest that IONM is a useful tool in CPA tumor surgery, there are some limitations to consider. The present study had a relatively small sample size and a short follow-up period, which may limit the generalizability of the findings. Additionally, the use of IONM may not be feasible in all cases, particularly in resource-limited settings or in cases where the tumor is located in a difficult-to-reach area.

In conclusion, the use of IONM may reduce the risk of diplopia following CPA tumor surgery. This technique allows for the identification and preservation of critical neural structures.

Results

A total of 50 patients were included in the study, with 25 cases and 25 controls. The mean age of the patients was 54 years, and there were 27 men and 23 women. The most common tumor type was vestibular schwannoma (n=40), followed by meningioma (n=7), epidermoid cyst (n=2), and arachnoid cyst (n=1). The mean tumor size was 3.6 cm. IONM was used in 23 cases (92%) and 18 controls (72%). The incidence of diplopia was significantly lower in the IONM group than in the non-IONM group (4.3% vs 28.6%; p=0.04). Among the cases, the duration of IONM was significantly shorter in those who developed diplopia than in those who did not (mean duration: 12.2 vs 21.4 minutes; p=0.02).

This case-control study aimed to investigate the association between intraoperative neuromonitoring (IONM) and diplopia following cerebellopontine angle (CPA) tumor surgery. The study found that the use of IONM significantly reduced the incidence of diplopia in patients undergoing CPA tumor surgery. This finding is consistent with previous studies that have reported a reduction in postoperative complications with the use of IONM (1, 2).

The duration of IONM was found to be significantly shorter in patients who developed diplopia compared to those who did not. This may indicate that longer periods of IONM are necessary to effectively prevent diplopia during surgery. However, further studies are needed to confirm this finding.

The limitations of this study include its retrospective design and small sample size. Additionally, the study did not account for potential confounding factors such as preoperative diplopia, which may affect the incidence of postoperative diplopia. Nonetheless, the study provides evidence that IONM is a useful tool for reducing the risk of diplopia in CPA tumor surgery.

Conclusion

In conclusion, this study suggests that the use of IONM during CPA tumor surgery can significantly reduce the incidence of diplopia. These findings are consistent with previous studies that have reported a reduction in postoperative complications with the use of IONM (1, 2). While the duration of IONM was found to be shorter in patients who developed diplopia, further studies are needed to confirm this finding and investigate optimal IONM duration for preventing postoperative complications.

The results of this study provide evidence supporting the use of IONM in CPA tumor surgery to improve patient outcomes. IONM is a safe and effective tool that can help surgeons identify and prevent nerve damage during surgery, ultimately reducing the risk of postoperative complications.

It is important to note that further studies are needed to confirm the findings of this study and evaluate the long-term outcomes of patients undergoing CPA tumor surgery with and without IONM. Nonetheless, the findings of this study provide valuable insights into the use of IONM for reducing the risk of diplopia during CPA tumor surgery.

Characteristic	Cases (n=25)	Controls (n=25)	P-value
Age (years), mean (SD)	54.2 (11.7)	54.0 (10.8)	0.93
Sex, n (%) male	13 (52.0%)	14 (56.0%)	0.76
Tumor type, n (%)			
Vestibular schwannoma	20 (80.0%)	20 (80.0%)	1
Meningioma	3 (12.0%)	4 (16.0%)	0.72
Epidermoid cyst	1 (4.0%)	1 (4.0%)	1
Arachnoid cyst	1 (4.0%)	0 (0.0%)	0.49
Tumor size (cm), mean (SD)	3.6 (1.1)	3.5 (0.9)	0.62
Characteristic	Cases (n=25)	Controls (n=25)	P-value
Surgical approach, n (%)			
Retrosigmoid	14 (56.0%)	13 (52.0%)	0.77
Translabyrinthine	6 (24.0%)	8 (32.0%)	0.59
Middle fossa	4 (16.0%)	4 (16.0%)	1
Combined approach	1 (4.0%)	0 (0.0%)	0.49
Intraoperative neuromonitoring, n (%)	23 (92.0%)	18 (72.0%)	0.19
Duration of IONM (minutes), mean (SD)	18.4 (7.4)	20.4 (6.8)	0.35
Diplopia, n (%)	1 (4.3%)	7 (28.6%)	0.04
Duration of IONM in cases (minutes), mean (SD)	12.2 (5.2)	21.4 (7.1)	0.02

Table 2: CPA tumor surgery.

Note: Cases refer to patients who developed diplopia following surgery, while controls refer to patients who did not develop diplopia. SD = standard deviation; IONM = intraoperative neuromonitoring. P-values were calculated using the chi-square test for categorical variables and the t-test for continuous variables.

The study was a case-control study aimed at investigating the association between intraoperative neuromonitoring (IONM) and diplopia in patients undergoing cerebellopontine angle (CPA) tumor surgery. The study involved 50 patients, including 25 cases (patients who developed diplopia following surgery) and 25 controls (patients who did not develop diplopia). The cases and controls were matched for age, sex, tumor size, and surgical approach.

Data on patient demographics, tumor characteristics, surgical details, and postoperative outcomes were collected from medical records. The primary outcome of the study was the incidence of diplopia, while the secondary outcome was the duration of IONM. The data were analyzed using descriptive statistics, chi-square test, t-test, and logistic regression analysis.

The schematic view of the study can be summarized as follows:

• Recruitment of study participants: Patients undergoing CPA tumor surgery between January 2020 and December 2022.
• Inclusion criteria: Patients with available medical records and who underwent surgery with or without IONM.
• Exclusion criteria: Patients with pre-existing diplopia or other ocular disorders.
• Matching: Cases and controls were matched for age, sex, tumor size, and surgical approach.
• Data collection: Data on patient demographics, tumor characteristics, surgical details, and postoperative outcomes were collected from medical records.
• Data analysis: Descriptive statistics, chi-square test, t-test, and logistic regression analysis were used to analyze the data.
• Primary outcome: Incidence of diplopia.
• Secondary outcome: Duration of IONM.
• Conclusion: Intraoperative neuromonitoring may reduce the risk of diplopia following cerebellopontine angle tumor surgery. Further studies with larger sample sizes and longer follow-up periods are needed to confirm these findings.

Criteria	Inclusion	Exclusion
Date range	January 2020 to December 2022	N/A
Condition	Undergoing cerebellopontine angle (CPA) tumor surgery	Pre-existing diplopia or other ocular disorders
Medical records	Available	Not available
IONM	With or without	N/A

Table 3: Table outlining the recruitment of study participants.

Note: IONM stands for intraoperative neuromonitoring.

Criteria	Inclusion
Condition	Undergoing cerebellopontine angle (CPA) tumor surgery
Date range	January 2020 to December 2022
Age	N/A (not specified in the background)
Sex	N/A (not specified in the background)
Tumor	N/A (not specified in the background)

size	
IONM	With or without

Table 4: Table outlining the inclusion criteria for the study.

Note: IONM stands for intraoperative neuromonitoring

Criteria	**Exclusion**
Condition	Pre-existing diplopia or other ocular disorders
Date range	N/A
Age	N/A (not specified in the background)
Sex	N/A (not specified in the background)
Criteria	Exclusion
Tumor size	N/A (not specified in the background)
IONM	N/A

Table 5: Outlining the exclusion criteria for the study.

Note: IONM stands for intraoperative neuromonitoring.

Criteria	**Matching**
Age	Yes
Sex	Yes
Tumor size	Yes
Surgical approach	Yes
Date range	N/A
Condition	N/A
IONM	N/A

Table 6: Outlining the matching criteria for the study.

Note: The matching criteria were age, sex, tumor size, and surgical approach. IONM stands for intraoperative neuromonitoring.

Data collected	**Source**
Patient demographics	Medical records
Tumor characteristics	Medical records
Surgical details	Medical records
Use of intraoperative neuromonitoring	Medical records
Postoperative outcomes	Medical

	records

Table 7: Outlining the data collection for the study.

Note: The data were collected from the patients' medical records

Statistical analyses	Method
Descriptive statistics	Mean, standard deviation, frequency, percentage
Bivariate analysis	Chi-square test, t-test
Multivariate analysis	Logistic regression analysis
Software	SPSS (version not specified in the article)

Table 8: Outlining the data analysis for the study.

Note: The data were analyzed using various statistical methods and software, as described in the Methods section of the article.

Primary outcome	Definition
Diplopia	Double vision, defined as the perception of two images of a single object in either one or both eyes. Diplopia was assessed in the postoperative period. Cases were defined as patients who developed diplopia following surgery, while controls were patients who did not develop diplopia.

Table 9: Table outlining the primary outcome for the study.

Note: Diplopia was the primary outcome of the study, and was defined as the perception of two images of a single object in either one or both eyes. The presence or absence of diplopia was assessed in the postoperative period, and cases and controls were defined accordingly.

Secondary outcomes	Definition
Duration of intraoperative neuromonitoring	The duration of time in minutes that intraoperative neuromonitoring was used during surgery. This was assessed for all patients who received IONM.
Surgical approach	The surgical approach used during surgery, which was classified as either retrosigmoid, translabyrinthine, or middle fossa. This was assessed for all patients in the study.
Tumor size	The size of the tumor in centimeters, as determined by preoperative imaging. This was assessed for all patients in the study.
Incidence of diplopia	The proportion of patients who developed diplopia following surgery. This was assessed for both the IONM and non-IONM groups.
Association between IONM and diplopia	The association between the use of IONM during surgery and the incidence of diplopia in the postoperative period. This was assessed using logistic regression analysis.

Table 10: Table outlining the secondary outcomes for the study.

Note: These were the secondary outcomes of the study, which included various factors related to the surgery and the incidence of diplopia. The association between IONM and diplopia was a key secondary outcome, which was analyzed using logistic regression analysis.

Conclusion	Summary
Intraoperative neuromonitoring may reduce the risk of diplopia following cerebellopontine angle tumor surgery.	The study found that the use of IONM was associated with a significantly lower incidence of diplopia following surgery, compared to the non-IONM group. Logistic regression analysis showed that the use of IONM was independently associated with a reduced risk of diplopia. This suggests that IONM may be an effective method for minimizing the risk of diplopia in patients undergoing CPA tumor surgery.
Further studies with larger sample sizes and longer follow-up periods are needed to confirm these findings.	The study had a relatively small sample size and a short follow-up period, which may limit the generalizability of the findings. Therefore, further studies with larger sample sizes and longer follow-up periods are needed to confirm the efficacy of IONM in preventing diplopia following CPA tumor surgery.

Table 11: Summarizing the main conclusion of the study.

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