



CLINICAL STUDY

OBJECTIVE AND SUBJECTIVE EVALUATION OF HEARING LOSS AFTER SPINAL ANESTHESIA USING PURE-TONE AUDIOMETRY AND TRANSIENT-EVOKED OTOACOUSTIC EMISSIONS

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SUMMARY

Objective: To evaluate the hearing loss after spinal anesthesia using objective and subjective hearing assessment tests.
Methods: Thirty male patients aged between 20 and 50 years who underwent orthopedic lower extremity surgery between June 2018 and December 2018 were included in the study. Demographic findings such as age, height, weight, volume replacement during surgery and duration of the surgery were recorded for the patient group. Pure tone audiometry and transient-evoked otoacoustic emission (TEOAE) tests were applied in each patient once preoperative and postoperative tests.

Results: The present study consists of data from 60 ears of 30 patients. Frequency-specific audiometric results were significantly different between preoperative and postoperative day one results at 0.25 and 0.5 kHz ($p = 0.004$). In the study group, no difference in TEOAE response amplitude was detected at any frequency on postoperative day one. Regarding TEOAE results, there was no statistically significant difference between preoperative and postoperative day one results for 60 ears ($p > 0.05$).

Conclusion: Our results indicate that spinal anesthesia results in a low frequency subjective hearing loss with no objective significance. Clinicians should be cautious about this, inform patients before the surgery and deliver the anesthesia with the thinnest diameter needle possible.

Keywords: Hearing loss; spinal anesthesia; pure tone audiometry; otoacoustic emissions

SAF TON ODYOMETRİ VE GEÇİCİ UYARILMIŞ OTOAKUSTİK EMİSYON KULLANILARAK SPİNAL ANESTEZİ SONRASI İŞİTME KAYBININ OBJEKTİF VE SUBJEKTİF DEĞERLENDİRMESİ

ÖZET

Amaç: Objektif ve subjektif işitme değerlendirme testlerini kullanarak spinal anestezi sonrası işitme kaybını değerlendirmek.
Yöntem: Haziran 2018 ve Aralık 2018 tarihleri arasında ortopedik alt ekstremitte ameliyatı geçirmiş, 20-50 yaş arası 30 erkek hasta çalışmaya dahil edildi. Hasta grubu için yaş, boy, kilo, ameliyat sırasındaki sıvı alımı ve ameliyat süresi gibi demografik bulgular kaydedildi. Saf ton odyometri ve geçici uyarılmış otoakustik emisyon (GUOAE) testleri ameliyat öncesi ve ameliyat sonrası uygulandı.

Bulgular: Çalışmamız 30 hastanın 60 kulağından elde edilen verilerden oluşmaktadır. Frekansa özgü odyometrik sonuçlar preoperatif ve postoperatif birinci günde 0.25 ve 0.5 kHz'de anlamlı olarak farklıydı ($p = 0.004$). Çalışma grubunda, ameliyat sonrası birinci günde GUOAE yanıt amplitüdünde herhangi bir sıklıkta herhangi bir fark saptanmadı. GUOAE sonuçlarına bakıldığında, preoperatif ve postoperatif birinci gün sonuçları arasında 60 kulak için istatistiksel olarak anlamlı bir fark bulunmadı ($p > 0.05$).

Sonuç: Sonuçlarımız spinal anestezinin objektif bir önemi olmayan düşük frekanslı subjektif işitme kaybı ile sonuçlandığını göstermektedir. Klinisyenler bu konuda dikkatli olmalı, hastaları ameliyattan önce bilgilendirmeli ve anesteziyi mümkün olan en ince çaplı iğne ile iletmelidir.

Anahtar Sözcükler: İşitme kaybı; spinal anestezi; saf ton odyometrisi; otoakustik emisyon

INTRODUCTION

Spinal anesthesia is one of the most commonly used regional anesthesia methods. Rarely, it may cause temporary or permanent neurological problems. Hearing loss is one of the

rare but important complications of spinal anesthesia, and its etiology is not clear. Its incidence is between 0.2 % and 8 %¹. Also, the incidence of hearing loss at low frequencies measured in hearing tests that patients did not recognize after spinal anesthesia is reported to be between 9% and 93 %²⁻⁴. The reason why the frequency is so variable is that although hearing loss after spinal anesthesia has been defined, hearing loss may not be clinically noticeable in most patients. There are relatively few publications related to hearing loss after spinal anesthesia, and publications are mostly case reports²⁻⁴.

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Received: 26 June 2019, accepted for publication: 03 December 2019

Cite this article: Gökçe Z. V., Öztürk S., Paltura C., Revision Surgery For Nodal Recurrence of Papillary Thyroid Carcinoma KBB-Forum 2019;18(4):352-357



Due to the perforation of the dural membrane after spinal anesthesia and infiltration of cerebrospinal fluid (CSF), bilateral hearing loss can be seen at low frequencies⁵. The decrease in hearing loss is associated with decreased CSF pressure leading to perilymphatic hypotonia and endolymphatic hydrops. Among the causes of hearing loss, the changes in the labyrinth pressure and vestibulocochlear nerve dysfunction are thought to be related to a decrease in CSF pressure⁵. The amount of CSF leakage from dura with various needle tip types and diameters varies, and the level of hearing loss is significantly affected^{6,7}. A significant increase in the number of patients with hearing loss has been reported as the diameter of the spinal needle increases⁸. Hearing loss usually occurs at low frequencies and within 24-48 hours postoperatively and resolves within five to seven days^{3,4}.

Otoacoustic emissions (OAE) originating from movements of cochlear ciliary cells can be recorded by a sensitive microphone placed in the external ear canal⁹. This test is a fast, objective and easy method to demonstrate the cochlear function. Emission measurements are very sensitive, and the hearing loss can only be determined by the dysfunctional stage, whereas pure tone audiometry (PTA) is a subjective method and can only detect lesions that are formed.

In the literature, there are very few clinical studies on hearing loss after spinal anesthesia. In this study, it was planned to evaluate the hearing loss after spinal anesthesia using objective and subjective hearing assessment tests.

MATERIAL and METHODS

Study Design: The approval of the XXXXX University Institutional Review Board was obtained before the study. Thirty male patients with ASA I-II, aged between 20 and 50 years who underwent orthopedic lower extremity surgery between June 2018 and December 2018 were included in the study.

Patients with previous and other chronic diseases during the study, hearing loss due to drug use (ototoxic drugs such as aminoglycoside and salicylate), chronic otitis media, retracted

tympanic membrane-serous otitis media and those who had middle ear surgery were excluded from both groups.

Application of Spinal Anesthesia: Heart rate, noninvasive blood pressure, electrocardiography, and peripheral oxygen saturation were monitored during the operation. After the preoperative values were recorded, all patients were laid in a lateral decubitus position. Lumbar region was prepared under aseptic conditions and using a 25G Quincke needle (Spinocan; B. Braun, Melsungen, Germany) with its tip facing cephalic direction puncture through L3-4 interval was performed. After CSF drainage was seen, 3 mL (15 mg) 0.5 % bupivacaine was injected. All blocks were applied by the same experienced anesthesiologist. The patient was excluded from the study when multiple procedures were required. Patients were immediately taken to the supine position after the block. Sensory block level was evaluated by needle prick test. Hypotension was defined as a systolic pressure below 90 mmHg, and bradycardia as 45 bpm. Patients were offered 24 hours of bed rest and daily fluid intake of 2 liters postoperatively.

Outcome Parameters: Demographic findings such as age, height, weight, previous surgery, accompanying systemic disease, drugs used, volume replacement during surgery and duration of the surgery were recorded for the patient group.

Both of the audiological tests were applied in each patient once preoperative and postoperative tests. PTA (Interacoustic AC-33 Denmark 2000) and OAE (Interacoustic ILO 25 Denmark 2002) tests were performed in patients included in the study. Pure tone averages were determined between 250-6.000 Hz frequencies in all patients. The patients with conductive hearing loss, mixed type hearing loss, and sensorineural hearing loss (SNHL) were detected. Acoustic stapes reflexes (ASR) and tympanograms of the patients were evaluated at 500, 1000, 2000 Hz and ASRs were evaluated as absent or present. All patients underwent transient OAE testing. Patients who responded and did not respond to the test at least 3 frequencies were evaluated as "passed" and "failed", respectively.



Statistical Analysis: Statistical analysis of all data was done using the SPSS (Statistical Package for Social Sciences) 21 program. Frequency values, percentages, arithmetic averages and standard deviations of all data were calculated. The Kolmogorov-Smirnov test was used to determine whether the data conformed to normal distribution. Chi-square tests were used to determine the difference between groups. The difference between the data was considered significant if p value was below 0.05.

RESULTS

Demographic data of the patients and operation durations are given in Table 1. The present study consists of data from 60 ears of 30 patients.

In all patients lumbar puncture was successful on the first attempt. None of the

patients experienced postdural puncture headache, backache, or other adverse effects.

Conventional pure-tone audiometry values of the patients preoperatively and postoperative day 1 are given in Table 2. Frequency-specific audiometric results were significantly different between preoperative and postoperative day one results at 0.25 and 0.5 kHz ($p = 0.004$).

In the study group, no difference in TEOAE response amplitude was detected at any frequency on postoperative day one. Regarding TEOAE results, there was no statistically significant difference between preoperative and postoperative day one results for 60 ears ($p > 0.05$). All measurements at other frequencies were normal in all patients (Tables 3).

Table 1. Demographic data of the patients.

Descriptives		Patients (n=30)
ASA physical status (n)	I	14 (46.7 %)
	II	16 (53.3 %)
Age (year)		37.24 ± 8.64
Body mass index (kg/m ²)		
Volume replacement (mL)		1250 ± 245.2
Duration of the surgery (minutes)		62.46 ± 16.42



Table 2. Preoperative and postoperative pure tone audiometry results.

Frequency (kHz)	Preoperative	Postoperative Day 1	<i>p</i> Value
0.25	12.39 ± 6.05	16.02 ± 6.61	0.004
0.50	13.30 ± 5.17	13.50 ± 8.11	0.626
1.00	13.18 ± 3.75	14.68 ± 6.34	0.064
2.00	12.09 ± 5.83	13.25 ± 6.66	0.104
4.00	14.39 ± 6.95	14.80 ± 13.93	0.072
6.00	15.91 ± 12.91	15.11 ± 17.40	0.144

Table 3. Preoperative and postoperative transient evoked otoacoustic emission results.

		Preoperative	Postoperative Day 1	<i>p</i> Value
Response (dB SPL)		12.88 ± 4.42	11.59 ± 3.85	0.102
Reproducibility (%)		84.46 ± 8.21	86.42 ± 8.86	0.604
Stability (%)		96.46 ± 2.68	96.20 ± 2.62	0.262
Stimulus intensity (dB SPL)		86.35 ± 3.63	84.68 ± 4.28	0.128
Response signal-to-noise ratio	1.0 kHz	6.68 ± 4.46	6.24 ± 4.28	0.504
	1.4 kHz	12.86 ± 5.21	11.65 ± 5.08	0.094
	2.0 kHz	12.23 ± 5.16	12.26 ± 4.24	0.426
	2.8 kHz	12.67 ± 4.24	12.63 ± 4.64	0.622
	4.0 kHz	8.64 ± 5.24	7.38 ± 3.68	0.062

SPL, sound pressure level.



DISCUSSION

In the present study, we aimed to evaluate the hearing loss after spinal anesthesia using objective and subjective hearing assessment tests and revealed that spinal anesthesia results in a low frequency subjective hearing loss with no objective significance.

The most frequently suggested cause of hearing loss that can be seen after spinal anesthesia is leakage of CSF after dural puncture. As a result of CSF escape, intracranial and intracochlear pressure decrease. Falling perilymphatic pressure causes an increase in endolymphatic pressure and endolymphatic hydrops develops. Relatively endolymphatic hydrops, in particular involving the apex of the cochlea, cause the ciliary cells to move away from the basement membrane, resulting in low-frequency hearing loss.

Age of the patient is one of the factors affecting the hearing loss after spinal anesthesia. Lamberg et al. found that hearing loss after spinal anesthesia was 43% in elderly patients¹⁰. Gültekin and Özcan found that transient hearing loss more frequent in young people (<30 years) than the elderly (> 60 years)¹¹. Ok et al. could not find hearing loss in young patients (20-40 years)¹². In a study performed mostly in patients in the fourth decade, Gülcü et al. reported clinically significant (30 dB) hearing loss in one (1.6%) and subclinical (10-25 dB) hearing loss in 11 patients (20%) after spinal anesthesia with 25-G Quincke needle based on the results of pure-tone audiometry¹³. The frequency of hearing loss in spinal anesthesia has been shown to be higher in patients whose spinal anesthesia was performed using thick needles rather than thin needles. In their study, Özkan et al. monitored the hearing status of patients who were anesthetized by spinal needles with 22-G and 26-G diameters and reported that the rate of hearing loss was higher on the second postoperative day in the patients in whom 22-G needles were used instead of 26-G needles⁷. Loss of 250 Hz and 500 Hz frequencies in the 22-G needle was found to be more frequent in the left ear ($p < 0.05$). They concluded that dural tears and CSF leakage caused by a large spinal needle

increased the incidence of hearing loss. In a study using pencil tips and sharp-tipped needles at the same size, hearing loss after spinal anesthesia was reported to be greater in the patient population where a sharp tip needle was used¹⁴. In another study using needles with the same size and the same tip size, hearing loss was more common in young patients than in elderly patients¹¹. Fog et al. thought that thick needles increased CSF leakage, decreased CSF pressure, and pressure changes were transferred to the cochlear canal in the inner ear and reported that the deterioration in the membranous labyrinth accompanied the Reissner membrane to shift towards the scala vestibuli and thus cause hearing loss⁶. Although we used atraumatic 25-G spinal needles, observation of low frequency hearing loss suggests that a patient's age was more effective in hearing loss after spinal anesthesia than the diameter of the spinal needle.

Özkan et al. reported that hearing loss was more common at low frequencies⁷. Dreyer et al. determined that the most frequently hearing loss induced by spinal anesthesia occurred between 125 Hz and 250 Hz, while Olgay et al. and Lee et al. indicated that hearing loss was most often seen between frequencies of 250 - 500 Hz^{5,15,16}. It has been reported that hearing loss at low frequencies seen after spinal anesthesia can completely disappear within 15 days, and that the duration of hearing loss may be as long as 7 months to 2 years or permanent, unknown in patients with Meniere's disease characterized by an underlying loss of hearing and balance^{4,6}. Hearing loss after spinal anesthesia can also be seen with headache, tinnitus, and nausea². In our cases, the hearing loss occurred on the frequency of 250 Hz.

Eustachian tube dysfunction, middle ear effusion, and increased middle ear pressure can cause hearing loss. Diuretics, NSAID drugs, aminoglycosides, and antineoplastic drugs and their administration rate, duration and dose may also cause ototoxicity which is usually manifested by the high-frequency hearing loss¹⁷. Patients with retracted tympanic membrane or serous otitis media, and patients using ototoxic drugs have been excluded from the study.



Furthermore, our patients' hearing loss was at low frequency.

Hearing loss after spinal anesthesia usually begins 24-48 hours after the operation and is completely resolved within five to seven days. However, cases with permanent hearing loss have also been reported⁶. Treatment with hearing loss after spinal anesthesia is controversial. Hearing loss usually disappears within a few days without treatment. However, some cases of hearing loss persisting for months have been also reported in the literature¹⁸. Some authors argue that there is no need for treatment, while others do not recommend waiting for spontaneous recovery¹⁸.

The main limitation of our study was the small sample size which may cause a high probability of a type 1 error. Second limitation is the experience restricted to the outcomes of a single institution. Third, some details of history and factors that may influence the outcome may not be completely documented. Due to these restrictions, associations should be interpreted with caution.

CONCLUSION

Our results indicate that spinal anesthesia results in a low frequency subjective hearing loss with no objective significance. Clinicians should be cautious about this, inform patients before the surgery and deliver the anesthesia with the thinnest diameter needle possible. Studies with larger numbers of patients are needed to assess the effect of spinal anesthesia on auditory function.

ACKNOWLEDGEMENTS

The authors declare no competing interests.

No financial support was received for this paper.

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