Effect of Spinal Anaesthesia on Hearing Threshold

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Background: Hearing loss following spinal anaesthesia is a known yet uncommonly reported complication. This study was aimed at determining the incidence and type of hearing loss (HL) following spinal anaesthesia (SA) and the relationship with the size of spinal needle.
Methods: A prospective study of patients scheduled for spinal anaesthesia for surgery at the Operating room and Otorhinolaryngology department in a tertiary centre was undertaken. The audiometry was done and the pre- and post – anaesthesia results were compared.
Results: Ninety – four ears of 47 patients, 16 males and 31 females, age range between 21 and 63 years (mean ± SD= 41±5) were included. The duration of anaesthesia was between 90 and 150 minutes (mean ± SD= 116±9). HL was seen in 9 ears of 7 patients (15%) and tinnitus in 14 ears. The preoperative and postoperative BC PTA were 10 – 45dB (mean ± SD= 26± 5) and 25 – 65dB (mean ± SD=38±5) respectively, (P= 0.02) while the preoperative and postoperative AC PTA in the early frequency range (0-100Hz) were between 5 – 45dB (mean ± SD= 20± 5) and 25 – 50dB (mean ± SD=25±7) respectively, (P= 0.08). There was significant difference in the mean BC PTA between those who had procedure less than 1 hour, 37.2dB and those greater than 1 hour 38.4dB, (P=0.004). According to the Quincke needle sizes, the mean BC PTA among those who had 26G and 27G were 37.4dB and 38.1dB respectively (P=0.2).
Conclusion: HL complicating SA is significant and associated with duration of procedure thus should be included in informed consent for medico-legal and ethical reasons and measures must be taken to avoid the leak of cerebrospinal fluid.

Introduction

Spinal anaesthesia is one of the most frequent regional anaesthesia techniques in surgical interventions, being used in all procedures below the umbilicus[1-4]. The advantages over general anaesthesia includes, cost reduction and elimination of the need for endotracheal intubation thus reducing the risk of aspiration of gastric content, and respiratory infection.[4-7] However, technique is not suitable for procedures longer than two hours and difficult access/failed cerebrospinal fluid (CSF) tap may occur[7-9].

Hearing loss following spinal anaesthesia is a known yet uncommonly reported complication with incidence between 0.4% and 40%, affecting the low frequency range[4,5]. Other complications that have been reported included postural headache, nausea, vomiting, vertigo and urinary retention with incidence ranging between 0.4% and 17% [10,11]. The disruption of the endolymph /perilymph balance caused by the decrease CSF pressure has been proposed as the mechanism of hearing loss after spinal anaesthesia. Our hypothesis was that the resultant CSF leak in spinal anaesthesia procedure would be significant enough to lead to changes in the volume of the endolymph and clinical depression of the hearing acuity. The aim of this study was to determine the incidence of hearing loss after spinal anaesthesia, identify the frequencies of hearing involved and find the relationship between the size of spinal needle and hearing loss.

Patients and Methods

This was a prospective study evaluating hearing loss among adult patients undergoing spinal anaesthetic technique for surgery at the operating theatres of the University College Hospital, Ibadan.

The inclusion criteria were all adult patients scheduled for elective surgical procedure using spinal anaesthetic technique. While patients requiring emergency surgery and those with previous history of hearing impairment/ear disease were excluded.
The sample size was determined using Fischer's formula and recruitment into the study was commenced.

All the participants who gave consent to the study were recruited. A structured questionnaire was administered on interviewer basis to record the participant's biographic data, relevant clinical information on hearing impairment/ear disease and otological examination was done to rule out any underlying pathology. Following this, pure tone audiometry was done using Amplivox Model 2150 in a quiet side - room on the ward. Frequency range between 125 to 8000Hz was tested on both ears. This was followed by induction of spinal anaesthesia. This was performed by the anaesthetist via a subarachnoid injection at the L3-4 interspace by using a 26G or 27G - gauge Quincke needle with the patient in the sitting position, and 3 ml of 0.5% isobaric bupivacaine. Patient selection into the 26G or 27G spinal needle group was done randomly. The audiometry was repeated between the 2nd post - operative day. All auditory evaluation was conducted in a quiet side - room on the ward.*s* The main outcome variable was the pure tone average before and after spinal anaesthesia while the dependent variables were the sizes of the spinal needle and the duration of the anaesthesia. The data was initially explored using the Stata software. The variables were analyzed by unpaired t-test both for equal and unequal variance using the variance ratio function of the Stata software to determine the appropriate use of the Satterthwaite's correction for the degrees of freedom. A logistic regression analysis was used to control for confounding factors. The Stata software® was used and the level of statistical significance was set at $p< 0.05$ for all the analyses.

Results

The study included 94 ears in 47 patients, 16 males and 31 females age range between 21 and 63 years (mean $\pm$ SD= 41$\pm$5). The duration of anaesthesia was between 90 and 150 minutes (mean $\pm$ SD = 116$\pm$9) and indications were urethroplasty, transurethral endoscopic prostatectomy, lower limb amputation, transvaginal hysterectomy and elective caesarean section.

Hearing loss was seen in 9 ears of 7 patients (15%) and tinnitus in 14 ears. The preoperative and postoperative BC PTA were 10 – 45dB (mean $\pm$ SD= 26$\pm$ 5) and 25 – 65dB (mean $\pm$ SD=38$\pm$5) respectively, (P= 0.02) while the preoperative and postoperative AC PTA in the early frequency range (0-100Hz) were between 5 – 45dB (mean $\pm$ SD= 20$\pm$ 5) and 25 – 50dB (mean $\pm$ SD=25$\pm$7) respectively, (P= 0.08). Comparing the duration of procedure, the mean BC PTA among those who had procedure less than 1 hour and greater than 1 hour were 37.2dB and 38.4dB(P=0.004). Comparing the sizes of the spinal needle, the mean BC PTA among those who had 26G and 27G were 37.4dB and 38.1dB respectively (P=0.2).

The preoperative and postoperative AC PTA in the middle (speech) frequencies (1000-3000Hz) (20dBvs 25dB, P=0.2), and BC PTA was (28dB vs 34dB, P= 0.9). Similarly, no statistically significant difference was seen in high frequencies, the preoperative and postoperative AC PTA were (40dB vs 42dB, P=0.3) and BC PTA were (42dB vs 45dB, P=0.2).

Discussion

This study found the incidence of bone conduction hearing loss complicating spinal anesthesia to be 15%. This is comparable with the report of 7.5% by Yildiz et al.[12] In addition our finding revealed significant difference between the pre-anaesthesia and post-anaesthesia involving bone conduction in the early frequencies. This early frequency involvement is similar to the report of previous workers[7-11] Hussain et al[8] prospectively studied 35 women who were undergoing spinal anesthesia during

cesarean section. A comparison of pre- and postoperative pure-tone audiometry showed that 5 of these women developed a low-frequency hearing loss on the first postoperative day. Similarly, Kilickan et al[13] reported permanent, fluctuating sensorineural hearing loss (SNHL), disabling vertigo, and tinnitus following spinal anesthesia for cesarean section in a 25-year-old female. The recruitment score (SISI) was 95% at 2000 Hz on the right side and directional preponderance towards the right and the right canal paresis were evidenced by bithermal caloric testing. They inferred from their findings a cochlear pathology causing endolymphatic hydrops possibly induced by lumbar puncture for spinal anesthesia.

In an animal experiment, Walsted et al[14] drained CSF from 18 guinea pigs and compared their pre- and post-drainage electrocochleography results with those of 18 untreated control animals. They noted a slightly higher compound action potential threshold and latency in the CSF-drained group. Schaffartzik et al[11] suggested cerebrospinal fluid leakage via the spinal puncture hole as the factor involved; however low-frequency hearing loss was also found after general anesthesia which correlated with intraoperative volume replacement implying that cerebrospinal fluid leakage via the spinal puncture hole is not the only factor involved.

The proposed pathogenesis of hearing loss was that the cochlear aqueduct, which connects the perilymphatic space to the CSF-filled subarachnoid space, influences the relationship between low CSF pressure and hearing impairment. Patency is poor in the adult cochlear aqueduct, and it decreases throughout life[15]. In correlating changes in CSF pressure with perilymph pressure, Carlborg et al[16] performed experiments in cats with open and artificially disrupted cochlear aqueducts. They noted that CSF pressure and perilymphatic pressure equalized almost immediately when the aqueduct was open. When the aqueduct was closed, the shift toward equalization occurred more slowly and was usually incomplete. They hypothesized that equalization occurred as CSF flowed through small tributaries and possibly the fundus of the internal auditory canal when the cochlear aqueduct was disrupted[16]. They suggested that an obstructed aqueduct does not prevent equalization from occurring. If the aqueduct is patent, loss of perilymph via decreased CSF pressure may lead to an endolymphatic hydrops[16]. This condition resolves with either the release of endolymph through the endolymphatic sac, or the re-accumulation of perilymph through the aqueduct, or perhaps another mechanism. Endolymphatic hydrops is a pathologic correlate of Meniere's disease. Its early course shares a common characteristic with hearing loss after a clinically significant CSF leak caused by dural puncture. Both disorders are associated with a predominantly low-frequency hearing loss, as was seen in patients in this study.

The mechanism of hearing loss after spinal anaesthesia has also been attributed to the disruption of the endolymph /perilymph balance caused by the decrease CSF pressure[17]. The perilymph is the substrate of the inner hair cells and is present in the cochlea, it's a filtrate of the blood and CSF, and communicate with the subarachnoid space through the cochlear aqueduct[17, 18]. The CSF dynamics are important for auditory function of the inner ear. The puncture of the dura membrane results in CSF leak and a drop in CSF volume and pressure. The reduced subarachnoid pressure is transmitted into the inner ear via the cochlear aqueduct resulting in a transient reduction of perilymphatic pressure causing endolymphatic hydrops. This endolymphatic hydrops is associated with hearing loss[8.]

In addition it is known that there is passive diffusion as well as active transport of ions between the endolymph and the perilymph. The significant association found between the depressions of the BC PTA with duration of anaesthesia in this study further suggests that the hearing loss may be evidence of prolonged CSF leakage. In this study, the involvement of low frequencies may account for the paucity of self report of hearing loss after operation. The speech frequencies are mainly between 1000Hz and 4000Hz, a range in which there was no significant depression of hearing threshold.

However, there is need for ethical consideration of enlightening the patients. Although such hearing loss has been found to be transient with duration from 1-5 weeks[5-11]. Further follow up may be needed

on this; in addition, we did not consider the number of punctures into dural space before spinal anaesthesia was established. This could also affect the volume of CSF leakage and possibly changes in the hearing threshold.

It may also be important for medico legal reasons to obtain informed consent for spinal anaesthesia considering the high incidence of the hearing loss.

This study did not found significant difference in the post - anaesthesia hearing threshold between sizes 26G and 27G Quincke needle. This finding suggested that CSF leakage following the use of the two sizes of needles were comparable. In contrast, other workers have reported that hearing loss was related to the needle size.[19, 20] Öncela et al[19] reported significant difference in the hearing loss between size 25G and size 22G needle in the post-operative period. The hearing loss observed in the 25 G-spinal anaesthesia group was significantly ($P<0.01$) less than that seen in the 22 G group, although none of the patients had headache after spinal anaesthesia. It was concluded that pure tone audiometry is a more sensitive indicator of cerebrospinal fluid leakage than post-operative headache.

We conclude that bone conduction hearing loss is prevalent complication of spinal anaesthesia and duration of anaesthesia was a significant factor. The implications of this study are as follows: Spinal anesthesia must be performed carefully with measures taken to avoid leakage of CSF. Patients should be informed about the possibility of hearing loss after spinal anesthesia for medicolegal and ethical reasons.

References

1. Walsted A. Effects of cerebrospinal fluid loss on hearing. *Acta Otolaryngol.* 2000;543:95-98.
2. Lee C. Hearing loss after spinal anaesthesia. *Anesth Analg.* 1990; 71:561-569.
3. Michel O, Brusis T. Hearing loss as a sequel of lumbar puncture. *Ann Otol Rhinol Laryngol.* 1992; 101:390-394.
4. Day CJE, Shutt LE. Auditory, ocular and facial complications of central neural block: a review of possible mechanisms. *Reg Anesth.* 1996; 21:197–201.
5. Wang LP, Fog J, Bove M. Transient hearing loss following spinal anesthesia. *Anaesthesia.* 1987; 42:1258 - 1263.
6. Finegold H, Mandell G, Vallejo M, Ramanathan S. Does Spinal Anesthesia Cause Hearing Loss in the Obstetric Population? *Anesth Analg*. 2002; 95:198-203.
7. Erkan K, Sitki G, Cengiz D, Yasemin I, Muzaffer K. Evaluation of Hearing Loss after Spinal Anaesthesia with Otoacoustic Emissions. *Eur Arch Oto-Rhino-Laryngol*. 2006; 263:705-710.
8. Hussain SS, Heard CM, Bembridge JL. Hearing loss following spinal anaesthesia with bupivacaine. *Clin Otolaryngol Allied Sci.* 1996; 21:449-54.
9. Hafer J, Rupp D, Wollbrück M, Engel J, Hempelmann G. The effect of needle type and immobilization on postspinal headache. *Anaesthesist.* 1997; 46:860-866.
10. Hyderally H. Complications of spinal anesthesia. *Mount Sinai J Med*. 2002; 69:55-56.
11. Schaffartzik W, Hirsch J, Frickmann F, Kuhly P, Ernst A. Hearing loss after spinal and general anesthesia: A comparative study. *Anesth Analg.* 2000; 91:1466-1472.
12. Yildiz TS, Solak M, Iseri M, Karaca B, Toker K. Hearing loss after spinal anesthesia: the effect of different infusion solutions. *Otolaryngol Head Neck Surg*. 2007; 137:79-82.
13. Walsted A, Salomon G, Olsen KS. Low-frequency hearing loss after spinal anesthesia. Perilymphatic hypotonia? *Scand Audiol.* 1991; 20:211-215.
14. Wlodyka J. Studies on cochlear aqueduct patency. *Ann Otol Rhinol Laryngol.* 1978; 87:22-28.
15. Carlborg BI, Konrádsson KS, Carlborg AH, Farmer JC Jr, Densert O. Pressure transfer between the perilymph and the cerebrospinal fluid compartments in cats. *Am J Otol.*

1992; 13:41-48.
16. Becker WB, Naumann HH, Pfaltz CR. Ear nose and throat disease: a pocket reference. New York: Thieme Medical Publishers 1989.
17. Johkura K, Matsushita Y, Kuroiwa Y. Transient hearing loss after accidental dural puncture in epidural block. *Eur J Neurol.* 2000; 7:125-126.
18. Kiliçkan L, Gürkan Y, Ozkarakas H. Permanent sensorineural hearing loss following spinal anesthesia. *Acta Anaesthesiol Scand*. 2002; 46:1155–1157.
19. Oncel S, Hasegeli L, Zafer UM, Savaci S, Onal K, Oyman S. The effect of epidural anaesthesia and size of spinal needle on post-operative hearing loss. *J Laryngol Otol*. 1992; 106:783-787.
20. Fog J, Wang LP, Sundberg A, Mucchiano C. Hearing loss after spinal anesthesia is related to needle size. *Anesth Analg*. 1990; 70:517-522.