INCIDENCE OF HEARING LOSS IN YOUNG AND ELDERLY PATIENTS FOLLOWING SPINAL ANAESTHESIA FOR CYSTOSCOPY

by

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DECLARATION

I declare that the dissertation hereby submitted to the University of Limpopo, for the degree of Master of Medicine in Anaesthesiology has not previously been submitted by me for a degree at this or any other university; that it is my work in design and in execution, and that all material contained herein has been duly acknowledged.

LT MPHOLO (DR) 28 January 2011
Student Number: [redacted]

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DEDICATION

The work of this dissertation is dedicated to my family; my daughter (Donota), my son (Moabi) and my husband and friend (Mr Donald Mpholo). Without your love, understanding and unfailing support, this task would have been impossible to accomplish.

May the GOOD LORD always protect and bless you all.

ABBREVIATIONS

ASA:	American Society of Anaesthesiologists
CSF:	Cerebrospinal fluid
dB:	Decibels
HL:	Hearing Loss
Hz:	Hertz
PDPH:	Post-Dural puncture headache
SAB:	Subarachnoid block
GROUP Y:	Group of Young patients
GROUP E:	Group of Elderly patients
Std. Dev:	Standard Deviation

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1. ABSTRACT

Introduction: Multiple studies have described a variable incidence of transient hearing loss (hypoacousis) from 0.4% to 40% after subarachnoid block, especially in the low-frequencies range (125 – 500 Hz) [1, 2]. The mechanism of transient hypoacousis is attributed to leakage of cerebrospinal fluid, which leads to a decrease in perilymph pressure within the cochlear.

Hypothesis: The study hypothesis was based on an assumption that hearing loss is more frequent in young patients who undergo spinal anaesthesia in comparison with elderly patients.

Objective:

1) To determine the incidence of hearing loss after spinal anaesthesia in the young versus elderly patients.

Materials and Methods: Ninety-eight male patients (ASA 1 - 11) scheduled for cystoscopy under spinal anaesthesia were recruited for the study. Recruitment of patients for the study was age-dependent and was divided into two groups: One group (49 patients) had patients aged between 17 and 44 years (Group Y) and

the other group had 49 patients aged between 45 and 77 years made up group two (GROUP E). Subarachnoid injection at L3-4 was performed using a standard 22-gauge Quincke spinal needle with patients in the sitting position and 2,5 ml to 3 ml of 0.5% isobaric bupivacaine was administered. Patients were evaluated on the day before spinal anaesthesia by pure tone audiometry at three different frequency sounds viz. 125 – 500 Hz (Low frequency), 500 – 2000 Hz (Speech frequency) and at 2000 – 4000 Hz (High frequency). This assessment was repeated 48 hours after the spinal block was given.

Statistical Analysis: Analysis was descriptive providing information on the mean (or median) and standard deviation of the variables for each of the two groups. The results of the audiometry were analyzed using repeated measures analysis of variance and transformation to p-value. Differences in outcomes of the study between the two groups were recorded as being statistically significant if p-value is ≤ 0.05.

Results: No patient from the two groups developed hearing loss either at low or high frequencies. However, there was a statistically significant improvement in audiometric results (p-value ranging

from 0.0001 and 0.063) 48 hours post-surgery in the elderly group as compared with patients in the younger group.

Conclusion: The study revealed no hearing loss post-spinal anaesthesia in both groups. It did, however, show that the elderly group have better hearing acuity at all three frequency levels of sound compared to the younger group after spinal anaesthesia.

2. INTRODUCTION

Spinal anaesthesia is used in a variety of both elective and emergency surgical procedures below the level of the umbilicus [3]. The complications of spinal anaesthesia range from relatively common hypotension and headache to rare but potentially disastrous sequelae of meningitis or extradural haematoma [1]. Hearing loss has been described but it is not generally considered to be a common complication of this technique. Multiple studies have described a variable incidence of transient hearing loss (hypoacousis) from 0.4% to 40% after subarachnoid block (SAB) especially in the low frequency range of 125 – 500Hz [1, 2].

The mechanism of transient hypoacousis is attributed to leakage of cerebrospinal fluid (CSF) which often leads to decrease in perilymh pressure within the cochlea [4]. The size of the dural defect is dependent on the size of the needle used to perform the spinal anaesthesia and could be related to the observed decrease in hearing. Spinal needle tip and/or size difference might lead to CSF leakage and subsequently might influence hearing function. The age of the patient has been suggested to be an independent factor

which may also have an effect on hearing loss after spinal anaesthesia [5, 6].

The purpose of this study, therefore, is to evaluate the differences in hearing loss between young (17 – 44 years old) and elderly (45 – 77 years old) patients following spinal anaesthesia.

3. LITERATURE REVIEW

The anatomy and physiology of the inner ear (COCHLEAR):

The anatomy of hearing can be divided into (1) the peripheral part which is made of external, middle and inner ear and the cochlear and vestibular divisions of the auditory nerve and (2) the central part which consists of hearing pathways, the sub-cortical and cortical auditory centres and central balance mechanisms [(4)]. The cochlear is the auditory portion of the inner ear. It is a snail-shaped structure of 2.75 cm and turns with an uncoiled length of approximately 3 cm (see Figure 1). The cochlear is divided into three channels: the scala vestibuli, the scala media and the scala tympani. The two outer channels, the scala vestibuli and scala tympani contain perilymphatic fluid and communicate at the apex through the helicotrema. The middle channel, the scala media (cochlear duct) contains the endolymph.

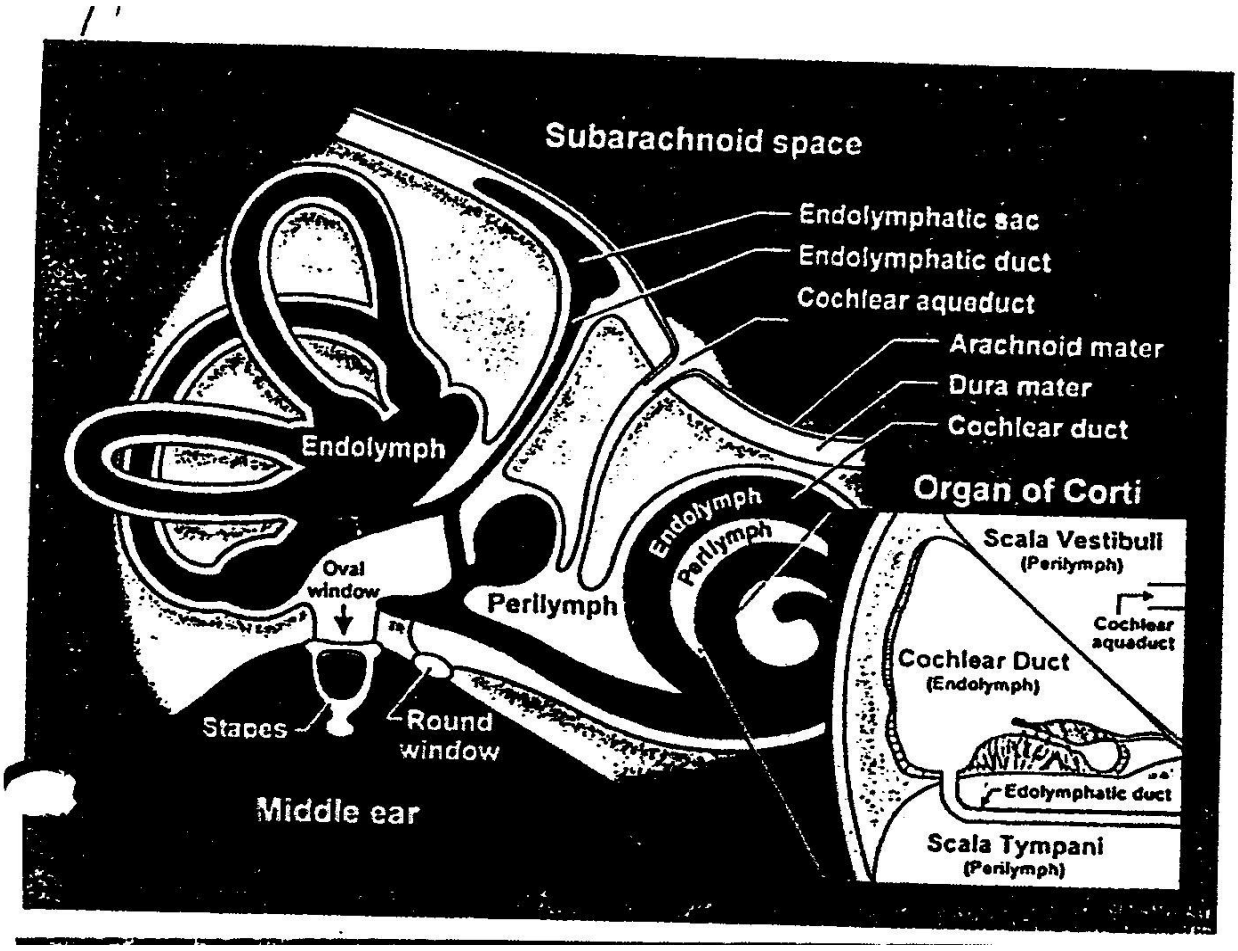

Figure 1: Diagram of the inner ear. Adapted from Journal of Clinical Anaesthesiology, 1995; vol.7:457– 464.

In the conventional cross-sectional view of the cochlear as shown in Figure 2, the scala media is triangular in shape. Its upper boundary, the vestibular membrane, attaches to the outer wall of the cochlear, separating it from the scala vestibuli. The lower boundary, the basilar membrane, also attaches to the osseous spinal lamina and the outer wall of the cochlear. The basilar membrane supports the hearing organ, the organ of corti and separates the scala media from scala tympani.

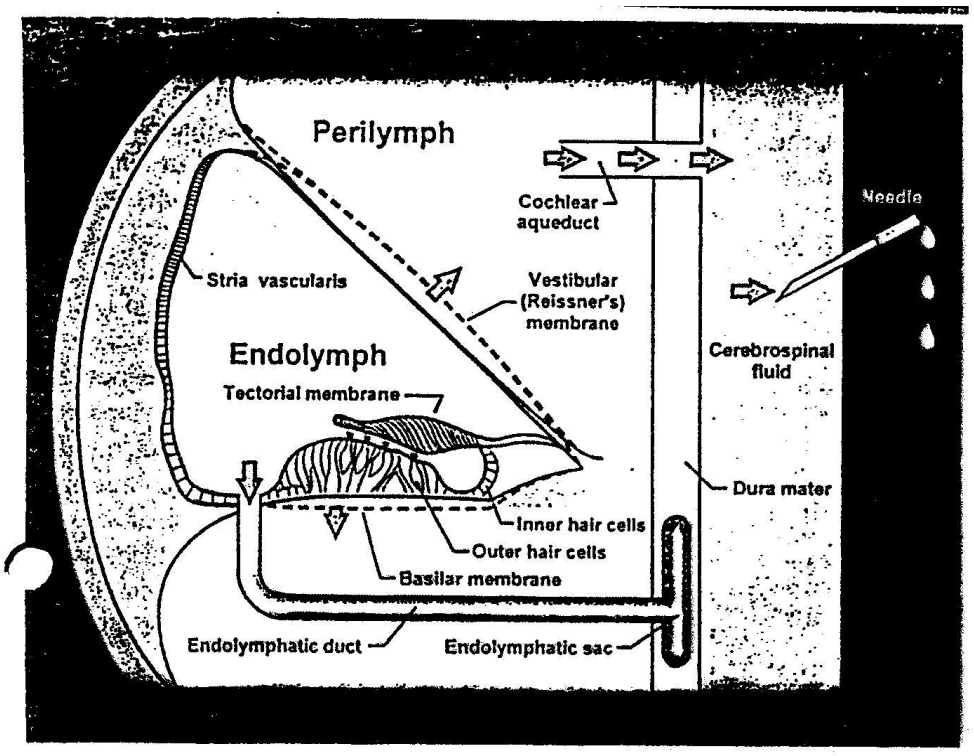

Figure 2: Cross-sectional diagram of the cochlear. Adapted from Journal of Clinical Anaesthesiology, 1995; vol.7: 457-464.

The lateral wall of the scala media is the highly vascular stria vascularis. At the base of the cochlear, the perilymph of the scala vestibular contacts the oval window and the perilymph of the scala tympani contacts the round window. These anatomical arrangements are shown in Figure 1 and in Figure 3.

Arterial blood supply to the inner ear is supplied through the internal auditory artery, which arises from either the basilar or the inferior anterior cerebellar artery and passes through the internal auditory meatus with the eighth cranial nerve; also known as vestibulo-cochlear nerve. The arterial supply to the cochlear is via

end vessels with no co-lateral circulation. The afferent special somatic exteroceptive cochlear nerve provides the innervations. The peripheral processes arise in the organ of corti, their cell bodies forming the special ganglion of the cochlear in the osseous spinal lamina. The processes converge, traversing the modiolus to form the cochlea nerve, which then passes through the inner acoustic meatus with the vestibular nerve. A smaller number of efferent nerve fibres arise from the olivary complexes and terminate axodendrically on the afferent dendrites that innervate the inner hair cells.

The cochlear fluid system is made up of two fluids: perilymph and endolymph as shown in figure 2.

The Perilymph:

- The fluid fills the scala vestibule and scala tympani.
- Has an ionic composition, low in potassium and high in sodium. .
- It is similar to intestinal fluid and identical to CSF.
- There are two theories to its origin (1) that it is a filtrate produced by capillaries in the spiral ligament and (2) it is CSF communicated to the cochlear through the cochlear aqueduct, a

small channel in the temporal bone near the round window, which connects the scala tympani directly to the subarachnoid space.

The Endolymph:

- The fluid is unique to the inner ear.
- Fills the scala media.
- Has a high concentration of potassium and low in sodium.
- It is similar to intracellular fluid.
- The stria vascularis is the source of the unique endolymph ionic composition.

Organ of Corti: The function of the organ of corti, which is the hearing transduction mechanism, is located in the cochlear duct (scala media). The sensory cells of the organ of corti are mechano-receptors with stereocilia projecting from the top of the cells into the endolymph.

There are two types of hair cells, the outer and the inner hair cells. The inner hair cells and outer hair cells initiate the transduction process by transforming the acoustic signal into neural activity. Activation of the hair cells causes neurotransmitter release that depolarizes afferent dendrites causing an all-or-none spike discharge in individual auditory nerve fibres. The neural signals initiated by the inner and outer hair cells are transmitted through

the acoustic division of the eighth cranial nerve and ultimately to the auditory cortex of the temporal lobe.

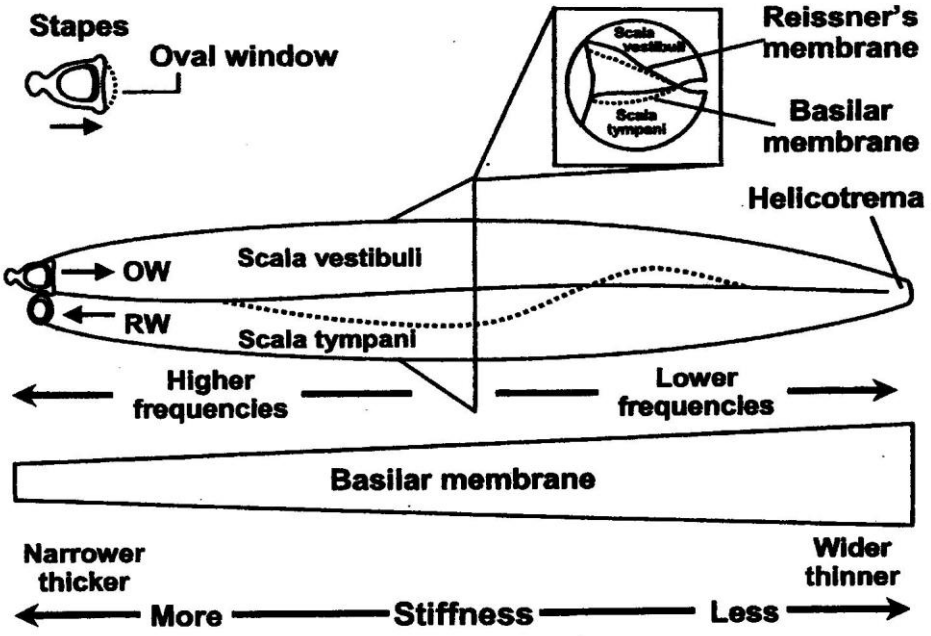

Figure 3: Schematic diagram of the uncoiled cochlear. Adapted from European Journal of Anaesthesia, 1998; vol. 15: 61- 63

Figure 3 illustrates the diagram of the cochlear uncoiled and it is usually used to describe cochlear mechanics. On the left is the base of the cochlear with the stapes and oval window. Below these structures and adjoining the scala vestibule is the round window of the scala tympani. Also in the diagram, the uncoiled cochlear is divided horizontally by a line representing the scala media, Reissner's membrane, the organ of corti and the basilar membrane. However, this line, for the purpose of understanding cochlear mechanisms, can be thought of as simply the basilar membrane. Above the dividing line is the scala vestibuli and below it, the scala

tympani. As a result of the inertia of the fluid mass and functional resistance to fluid flow in the narrow channels of the scala, inward or outward motion of the stapes against the oval window causes a pressure wave to travel down the scala, there is no fluid flow.

Since these fluids are incompressible within the bony cochlear, the pressure wave travelling down the scala vestibuli causes the basilar membrane to deflect downward towards the scala tympani for positive pressure and upward for negative pressure. The flexible round window compensates for pressure changes transmitted to the scala tympani. For the acute changes caused by pressure wave in the audible frequencies, the connection between the scala vestibuli and the scala tympani, the helicotrema, function as though it were closed. The helicotrema is only involved in very slow equalization of pressure between the two scalae.

The important property of the basilar membrane is its ability to separate various frequencies. The compliance of the basilar membrane changes by a factor of greater than 100 from base to the apex. At the base, near the oval window, the basilar membrane is narrower and thicker, making it less compliant (see Figure 3). It is wider and thinner at the apex, resulting in greater compliance. The basilar membrane functions as a finely tuned bandpass filter,

performing a spectral analysis on the in-coming sound waves. The effect is to translate the frequency of in-coming sound into distance along the basilar membrane – a frequency-to-place or tonotopical transformation. Therefore, both the inner hair cells and outer hair cells at a specific point along the basilar membrane responds to a very specific, narrow frequency range. Excited hair cells depolarize specific acoustic neurons and the information is finally interpreted in the auditory centres [(6)].

The exposé on the anatomy of the inner ear (cochlear) given in the previous section, is considered pertinent to this study, so as to fully illustrate the inter-play of the various structures that together, function to enable an individual to possess acoustic ability. It also provides the necessary understanding of how hearing ability can become dysfunctional for a variety of reasons.

Hearing loss (HL) and neural anaesthesia

Multiple studies have described a variable incidence of transient HL from 0.4 % to 40% after subarachnoid block (SAB), especially in the low frequency range. The work of Vandam and Dripps cited by Spring et al [(6)] reported that out of 9277 patients who had spinal anaesthesia, 0.4% experienced auditory difficulties such as hearing loss, tinnitus, buzzing or roaming.

Hearing loss following spinal anaesthesia can be clinical or sub-clinical but most often it is sub-clinical and may go unnoticed unless audiometry is performed. The precise incidence of clinical or sub-clinical HL is unknown because no large audiometric studies of HL associated with spinal anaesthesia have been done and may occur frequently than appreciated. Hearing loss is almost uniformly in the lower frequencies usually between 125 – 1000 Hz but the hearing defect can be as high as 2000 Hz and it does not occur at higher frequencies [6].

Hypoacousis may be conductive, sensorineural, unilateral or bilateral. It occurs usually within the first 24 hours post-spinal anaesthesia, although cases of it occurring later than 48 hours have been reported [2, 7]. Post spinal HL resolves spontaneously within a few days (3 – 5 days) [2]. If it persists for several months, epidural blood patch has been used successfully to resolve the hearing impairment [8]. Permanent HL after spinal anaesthesia requiring long term follow-up has been reported [2,6,9,10].

Several aetiological factors have been postulated to explain the hearing impairment following neuraxial anaesthesia. The investigated factors are: (i) needle gauge, (ii) needle type, (iii) anaesthetic agent used and (iv) the age of the patient.

Needle Gauge: The size of the needle used for dural puncture appears to play a role in post-spinal anaesthetic hearing impairment. Fog et al [(11)] found that 13 out of 14 patients whose spinal anaesthesia was performed with a 22-gauge needle had a 10-decibel (dB) or greater hearing loss across the audible frequency range with significant greater losses in the low frequency range. Only four of the 14 patients in whom a 26-gauge needle was used had similar hearing impairment and none of them had significant (> 10 dB) hearing loss. Oncel et al [(9)] used a pure tone audiometry pre-operatively and post-operatively to assess HL in three groups of patients. One group received epidural anaesthesia and for the other two groups, spinal anaesthesia was performed with either a 22 or a 25-gauge needle. No hearing impairment was detected in the epidural group. There was a significantly greater hearing loss in the group for whom a 22-gauge needle was used as compared with the 25-gauge needle group.

Needle Type: Sundberg et al [12], using audiometry compared the effect of 22-gauge cutting tip needle (Quincke) to a 22-gauge pencil point (Whitacre) needles on post-spinal hearing loss. A HL of at least 10dB at two or more frequencies below 1000 Hz was observed in 6 out of 25 patients (24%) in the Quincke group compared to 2 out of 23 (9%) in the Whitacre group.

Anaesthetic Agent: Gultekin et al [13] used pure tone audiometry to test hearing ability before and after spinal anaesthesia for hernia repair. They compared the effects of 2% prilocaine and 0.5% bupivacaine in hearing loss following spinal anaesthesia. Patients given prilocaine were more likely to develop HL (10 out of 22 patients) than those who were given bupivacaine (4 out of 22 patients). The study concluded that HL was less frequent when the anaesthetic agent was bupivacaine rather than prilocaine.

Age of Patients: The ages of patients have been reported to affect HL following anaesthesia. Low frequency HL after spinal anaesthesia has been reported in older patients. Wang et al [2] reported significant changes in hearing (> 10 dB) in 6 out of 14 patients (median age of these patients was 65 years) within the low frequency range of 125 to 500 Hz. Gulay et al [5] did a study to

assess HL in young adult patients (aged 20 to 40 years) after spinal anaesthesia comparing spinal needle size and were unable to induce HL in the young patients undergoing spinal anaesthesia by injecting the anaesthetic agent with a 22-gauge or a 25 gauge Quinicke needle. Gutlekin et al **(10)** examined HL after spinal anaesthesia in young and old patients and reported higher incidence of transient HL in young patients.

CSF pressure and HL: CSF leakage can cause a decrease in the CSF pressure that may be transmitted to the inner ear. A relative balance in the endolymphatic and perilymphatic pressure maintains the normal structure conformation in the inner ear. Disruption of this pressure balance can cause hearing impairment as well as impairment of the semicircular canal function. A change in the CSF pressure is transmitted through a patent cochlea aqueduct to the inner ear perilymph (see Figure 2). A decrease in CSF pressure following a dural puncture and CSF leakage would cause a rapid and similar decrease in perilymph pressure. The endolymphatic system, responds much more slowly. Endolymphatic pressure-volume adjustments are primarily the result of altered absorption at the endolymphatic sac. Therefore, an acute drop of CSF pressure could result in endolymphatic pressure, sufficiently exceeding that

of the perilymph as to cause distortions to both Reissner's membrane and the basilar membrane. The consequent disruption in the position of hair cells results in hearing impairment. This mechanism has been postulated in several previous studies [1,2,4,5,6].

Post spinal HL and post-dural puncture headache (PDPH) share a common etiology: leakage of CSF from the subarachnoid space. Hearing impairment following neuraxial anaesthesia seems to be related to the same factors (age, needle gauge and needle type) that are implicated in PDPH. A direct relationship between HL and PDPH has not been established [4, 6, 9].

Sprung et al [6] suggest that the reason why every patient with PDPH does not experience HL following spinal anaesthesia is that 7% of adults have anatomically obstructed cochlear aqueducts and 30% have a functionally obstructed aqueduct. For these patients, CSF pressure changes are not transmitted to the perilymph and therefore a severe PDPH could exist without a hearing defect.

Most of the hearing deficit that result from lumbar puncture or CSF loss occur in the low frequencies and is bilateral. Sprung et al [6] proposed that this is the result of the physical characteristics of the

basilar membrane. At the cochlear base where the higher frequencies are transduced, the basilar membrane is narrow, thick and stiff and therefore resistant to pressure changes that are not in its resonant frequency range (Figure 3).

At the cochlear apex, where the low frequencies are transduced, the basilar membrane is much more compliant. Changes in CSF pressure transmitted to the perilymph can cause significant static displacement of the basilar membrane, disrupting the normal outer hair cells relationship to the tectorial membrane and resulting in low frequency hearing loss.

4. ETHICAL ISSUES

The conduct of this study was made possible through the participation of patients admitted at DR GEORGE MUKHARI HOSPITAL(DGMH) for cystoscopy. An informed and signed consent was given by each patient after having explained the content of the consent form. Permission to carry out the study was given by the Clinical Superintendent of DGMH and the protocol for the study was approved by the Institutional Review Committee (MREC) of University of Limpopo (Medunsa Campus) – with Clearance Certificate Number (MREC/M/17/2008:PG). Strict measures were put in place to ensure the anonymity and confidentiality of those patients who participated in the study.

5. AIM

The aim of my study is to evaluate the difference of hearing loss between young and elderly patients who underwent cystoscopy following spinal anaesthesia.

6. OBJECTIVE

1) To determine the incidence of hearing loss after spinal anaesthesia in young versus elderly patients.

7. MATERIALS & METHODS

7.1Study population and patient selection: Ninety eight (98) patients were selected for the study, using the American Society of Anaesthesiologist (ASA) physical status I and II. Adult male patients between the ages of 17 – 77 years scheduled for cystoscopy under spinal anaesthesia were included for the study. An informed and signed consent for inclusion into the study was sought and obtained from each patient during the pre-operative visit. The 98 patients were stratified into two groups: Forty-nine (49) patients aged between 17 and 44 years formed the young group (Group Y) and the remaining forty-nine patients aged between 45 and 77 years constituted the elderly group (Group E).

Exclusion criteria: The following table lists the criteria for excluding any patient from the study.

TABLE 1: Exclusion Criteria

1	Any patient unable or unwilling to give informed consent
2	Patients rated ASA III or more.
3	Patients who declined spinal anaesthesia
4	Patients who were unable to co-operate with audiometric testing
5	Patients who had contraindications to spinal anaesthesia
6	Patients with a history post-dural puncture headache (PDPH)
7	Patients with previous hearing problems
8	Patients on medication that could cause hearing impairment

7.2Equipment for audiometry: Hearing loss was assessed by pure tone audiometry and tympanometry on the day prior to surgery and 48 hours post-operation. Pure tone audiometry was done using a calibrated AC 30 and AC33 Clinical Audiometers manufactered by Interaccustics and pure tone thresholds were recorded in the following frequencies:

1) ***Low Frequency***: 125 – 500 Hz

2) ***Speech Frequency***: 500 – 2000 Hz

3) ***High Frequency***: 2000 – 4000 Hz

Tympanometry was carried out using a calibrated GSI Tympostar manufactured by Grason Stadler to assess middle ear pathology. Audiometry testing and tympanometry were done by qualified audiometrists at the Department of Audiology of the University of Limpopo (Medunsa Campus).

7.3 Table 2: Standard Procedure used for Spinal Anaesthesia:

1	Patients were pre-medicated with 2 mg/kg of hydroxyzine (Aterax) one hour before the procedure.
2	All patients received a 500ml bolus of Ringer's lactate before spinal anaesthesia.
3	A 22-gauge Quincke needle
4	2,5 – 3 ml of 0.5% bupivacaine
5	Spinal anaesthesia was administered into L3-4 inter-space with a mid-line approach and with the patient in the sitting position. Only one dural puncture was made in patients and if there was doubt about a second dural puncture, the patient was excluded from the study.
6	Sitting for two minutes once spinal sited.
7	Then supine, once the level of anaesthesia (sensory level of T10) was determined by pin –prick testing the patients were put in lithotomy position and surgery was permitted.
8	Intra-operative monitoring: 1) Non-invasive blood pressure 2) Electrocardiogram 3) Heart Rate 4) Pulse Oximeter
9	Post-operative fluids, Ringer's lactate 1000 ml over 12 hours.

7.4Data collection: Patients were taken for audiometric and tympanometric testing a day prior to the procedure and the test was repeated 48 hours after spinal anaesthesia. A Data collection form

was used for each patient to record the following variables (Appendix 1).

1) Age of patient
2) Weight of patient (Kg)
3) Height (Metres)
4) Pre-operative fluid given.
5) Amount/volume of bupivacaine given
6) Pre-medication
7) Post-operative analgesia
8) Post-operative dura puncture headache
9) Baseline and post-operative audiometric results.

7.5Statistical Analysis: The statistical analysis was conducted using a computer statistical programme (Epi-Info version 6.0). Analysis was descriptive for which mean, median were established. Data generated from the study were analyzed using repeated measures analysis of variance, as well as standard deviation. Significant differences between baseline and post-operative values and differences between young and elderly patients were calculated using paired sample T-test and its transformation to p-value. Statistically significant differences were noted if p-value was $\leq$ 0.05

8. RESULTS

Demographic data (including age, weight and height) of patients is shown in Table 3. The elderly group (Group E) has a statistically significant heavier weight than the younger patients (Group Y). The two groups of patients had identical range of height with a p-value of (0.3811), indicating no statistical difference between the two groups. There was no evidence of local anaesthetic toxicity and none of the patients in the two groups complained of PDPH.

Table 3: Demographic data of patients in this study [Young and Elderly patients]

Variables	Young Patients (Y) [N = 49]	Elderly Patients (E) [N = 49]	p-value
Age (yrs)	Range: 17 – 44 Mean = 29.0 Std Dev. = 7.8	Range: 45 – 77 Mean = 60.8 Std Dev. = 8.2	-
Weight (Kg)	Range: 48 – 97 Mean = 59.5 Std Dev. = 8.0	Range: 47 – 95 Mean = 67.1 Std Dev. = 11.5	0.0003
Height (m)	Range: 1.57 – 1.74 Mean = 1.67 Std Dev. = 0.04	Range: 1.57 – 1.86 Mean = 1.68 Std Dev. = 0.07	0.3811

N = Number of patients in each group

Audiometric Results: For the purpose of this study, mild hearing loss was defined as a hearing impairment of 10 – 20 dB at two or more frequencies in either ear. Tympanometric examination

revealed no evidence of middle-ear disease in any of the patients over the entire study period.

Tables 4 and 5 show the mean ± (SD) of the pre- and post-operative pure tone hearing thresholds in the frequency sounds (Low frequency: 125 – 500 Hz; Speech frequency: 500 – 2000 Hz; High frequency: 2000 – 4000 Hz) for both Group Y (Table 4a; 4b & 4c) and Group E (Table 5a; 5b & 5c).

Table 4a: Baseline [Pre-operative] pure tone hearing thresholds for young patients at three frequency levels (N = 49)

	Low Frequency [125 – 500 Hz]	Speech Frequency [500 – 2000 Hz]	High Frequency [2000 – 4000 Hz]
Right Ear:			
Range	5 – 35	5 -35	5 – 40
Mean	12.6	15.15	15.33
Std Dev.	6.83	6.93	9.39
Left Ear:			
Range	5 – 32	5 – 48	5 – 80
Mean	12.32	13.94	16.41
Std Dev.	5.57	8.46	12.89

Table 4b: Hearing thresholds for young patients, 48 hours post-cystoscopy under spinal anaesthesia [N = 49].

	Low Frequency [125 – 500 Hz]	Speech Frequency [500 – 2000 Hz]	High Frequency [2000 – 4000]
Right Ear:			
Range	5 – 28	5 – 30	5 – 40
Mean	11.59	13.82	14.39
Std Dev.	4.68	5.23	8.31
Left Ear:			
Range	5 – 22	5 – 40	5 – 70
Mean	11.80	14.69	16.23
Std Dev.	4.90	7.65	11.20

Table 4c: Effects on hearing thresholds on young patients, 48 hours following spinal anaesthesia [N = 49].

Right Ear	Low Frequency: 125 – 500 Hz	t = 0.84	p = **0.4030***
	Speech Frequency: 500 – 2000	t = 1.06	p = **0.2918***
	High Frequency: 2000 – 4000 Hz	t = 0.52	p = **0.6043***
Left Ear	Low Frequency: 125 – 500 Hz	t = 0.49	p = **0.6253***
	Speech Frequency: 500 – 2000 Hz	t = 0.45	p = **0.6537***
	High Frequency: 2000 – 4000 Hz	t = 0.15	p = **0.8811***

p* = No Statistically significant difference.

There was no statistically significant difference in pure tone hearing threshold among the young patients following spinal anaesthesia for cystoscopy.

Table 5a: Baseline [pre-operative] hearing thresholds for elderly patients at three frequency levels (N = 49).

	Low Frequency [125 – 500 Hz]	Speech Frequency [500 -2000 Hz]	High Frequency [2000 – 4000Hz]
Right Ear:			
Range	5 – 65	8 – 60	5 – 65
Mean	16.7	22.4	30.2
Std Dev.	10.6	8.3	17.2
Left Ear:			
Range	5 – 33	5 – 53	5 – 65
Mean	14.7	21.5	31.0
Std Dev.	6.3	8.3	15.9

Table 5b: Hearing thresholds for elderly patients, 48 hours post-cystoscopy under spinal anaesthesia [N = 49].

	Low Frequency [125 – 500 Hz]	Speech Frequency [500 – 2000 Hz]	High Frequency [2000 – 4000 Hz]
Right Ear:			
Range	5 – 35	10 – 60	5 – 70
Mean	15.6	22.2	30.4
Std Dev.	6.6	9.2	16.8
Left Ear:			
Range	5 – 30	5 – 55	7 – 80
Mean	14.0	21.7	32.2
Std Dev.	6.5	9.0	16.6

Table 5c: Effects on hearing thresholds on elderly patients, 48 hours following spinal anaesthesia [N = 49].

Right Ear:	Low Frequency: 125 – 500 Hz	t = 0.60	p = **0.5499***
	Speech Frequency: 500 – 2000 Hz	t = 0.11	p = **0.9126***
	High Frequency: 2000 – 4000 Hz	t = 0.06	p = **0.9206***
Left Ear:	Low Frequency: 125 – 500 Hz	t = 0.54	p = **0.5904***
	Speech Frequency: 500 – 2000 Hz	t = 0.11	p = **0.9126***
	High Frequency: 2000 – 4000 Hz	t = 0.36	p = **0.7196***

p* = No statistically significant difference

There was no statistically significant difference [Baseline versus post-operative hearing test] in pure tone hearing threshold in the elderly patients following the use of spinal anaesthesia for cystoscopy.

Tables 6a and 6b illustrate the differences in hearing between young and elderly patients at the three frequency levels of hearing threshold, before and 48 hours after spinal anaesthesia.

Table 6a: Differences in hearing threshold between young and elderly patients prior to spinal anaesthesia [Baseline].

Right Ear:	Low frequency: 125 – 500 Hz	t = 2.25	p = 0.0267
	Speech Frequency: 500 – 2000 Hz	t = 4.65	p < 0.0001
	High Frequency: 2000 – 4000 Hz	t = 5.25	p < 0.0001
Left Ear:	Low frequency: 125 -500 Hz	t= 1.96	p = 0.0529
	Speech Frequency: 500 – 2000 Hz	t = 1.44	p = 0.1531
	High Frequency: 2000 – 4000 Hz	t = 4.90	p < 0.0001

Prior to spinal anaesthesia, elderly patients demonstrated better hearing thresholds than the young patients in the right ear at all three frequency levels and especially at speech and high frequencies. In the left ear, however, although elderly patients still demonstrated better hearing, this only occurred at high frequency.

Table 6b: Differences in hearing thresholds between young and elderly patients, 48 hours after spinal anaesthesia

Right Ear	Low frequency: 125 – 500 Hz	t = 3.50	p = 0.0007
	Speech Frequency: 500 -2000 Hz	t = 5.48	p < 0.0001
	High Frequency: 2000 – 4000 Hz	t = 5.93	p < 0.0001
Left Ear	Low Frequency: 125 – 500 Hz	t = 1.88	p = 0.0631
	Speech Frequency: 500 – 2000 Hz	t = 4.11	p < 0.0001
	High Frequency: 2000 – 4000 Hz	t = 5.50	p < 0.0001

Post-Surgery:

1) 48 hours following spinal anaesthesia, no hypoacousis was noted at any frequency over the entire testing period in the two groups of patients.

2) 48 hours following spinal anaesthesia the elderly patients showed increased acuity in all frequencies (that is low frequency, speech frequency and high frequency) than the young patients in the right ear.

3) In the left ear, 48 hours post-spinal anaesthesia the elderly patients had statistically significant ($p < 0.0001$) increased acuity in the left ear than the young patients at both speech and high frequencies (Table 6b).

9. DISCUSSION

This study evaluated the difference in HL between young and elderly patients following spinal anaesthesia. The results revealed no demonstrable HL in the two groups as a result of the use of spinal anaesthesia.

The etiology of vestibulo-cochlear dysfunction after spinal anaesthesia remains unclear. The most widely accepted mechanism is the leakage of CSF via a hole in the dura, causing a decrease in CSF pressure. Since there is a direct communication across the cochlear aqueduct between the perilymph and CSF, any change in the CSF pressure is reflected by a change in perilymph pressure within the cochlear. This creates an imbalance between perilymph and endolymph, distorting the relationship of hair cells and basement membrane and therefore damping the response to auditory inputs [(2)].

By using tympanic membrane displacement analysis, Schaffartzik et al [14] showed a positive correlation with low frequency HL and intra-operative fluid administration replacement during general and spinal anaesthesia. Because tympanic membrane displacement analysis is a sensitive method for intra-cochlear pressure measurements, any pressure change in the inner ear caused by CSF leakage from dural puncture can be detected. However, Schaffartzik et al found no change in tympanic membrane displacement pre-operatively or post-operatively. This development suggests that CSF leakage via dural puncture hole may not be the only factor involved in HL.

Although the needle gauge and needle types have been associated with possible HL after spinal anaesthesia, there is yet no consensus as to which needle gauge/type will prevent development of auditory defects post-spinal anaesthesia. Decreased CSF pressure after dural puncture has been suggested to be involved, and the use of large diameter needles increases the intensity of HL. Oncel et al [9] observed more HL when anaesthetic agent was injected with a 22-gauge needle than when 25-gauge spinal needle was used. Fog et al [11] reported a 92% incidence of decreased hearing level (> 10

dB) with the use of a 22-gauge spinal needle but only a 29% incidence with the use of a 26-gauge needle.

Sundberg et al [12] reported a 24% HL with the use of cutting needles and 9% with the use of pencil-point needles. In contrast to these studies Gulay et al [5] was unable to induce HL in young patients aged between 20 and 40 years who underwent spinal anaesthesia by injecting the anaesthetic agent with a 22-gauge and 25-gauge Quincke needles. Therefore, in this study a 22-gauge Quincke spinal needle was adopted and used.

The anaesthetic agent used in this study was 0.5% isobaric bupivacaine. Gultekin et al [13] did a study where they looked at the effect of different anaesthetic agents in hearing loss following spinal anaesthesia and reported that patients given prilocaine were more likely to develop HL than those given bupivacaine. They suggested that this difference may be caused by differences in the osmotic or other physical properties of the two local anaesthetic preparations, which affect the cerebrospinal pressures differently.

The age of a patient may also affect HL. Studies done by Wang et al [3] and Lamberg et al [15] have reported the occurrence of low frequency HL after spinal anaesthesia in older patients. In contrast

to those studies Gulay et al [5] did a study on young adult patients and could not detect any hearing loss.

Gultekin et al [10] did a comparative study between young and elderly patients where they compared the incidence of HL after spinal anaesthesia for men under the age of 30 years to that in men over 60 years of age. Fifty-two percent of the younger patients and sixteen percent of the older patients had significant HL of >10 dB confined to the low frequency ranges of between 125 – 500 Hz. There was no hearing impairment in the speech frequency (500 – 200 Hz) and high frequency (2000 – 8000 Hz) for either group. The study concluded that transient HL was more common in young patients after spinal anaesthesia than in elderly patients.

This finding seems contradict the observations in the present study in that: (1) there was no HL demonstrated in any of the patients in the two groups up to 48 hours post-spinal anaesthesia. Secondly, 48 hours following spinal anaesthesia, the elderly patients showed increased acuity at all frequencies in the right ear than in the young patients. In the left ear, the elderly patients had increased acuity at speech and high frequencies than in patients in the younger group.

Two previous studies have shown similar results to those found in my study. One was a study conducted by Fog et al [11] and the other was by Finegold et al [4]. In the study by Fog et al [11] audiograms were performed pre-operatively and 2 days post-operatively in 28 patients who were given spinal anaesthesia for transurethral resection of the prostate. Hearing loss of 10 dB or more at any frequency was observed in 13 out of 14 patients (92.9%) in the 22-gauge group and in 4 out of 14 patients (28.6%) in the 26-gauge group. There was a statistically significant reduction in hearing level in the low frequency range in patients in whom the 22-gauge needle was used. They also observed an increase in hearing level in some patients in the high frequency range.

The purpose of the study by Finegold et al [4] was to determine whether any hearing loss occurs in the obstetric population after regional anaesthesia and whether the shape of the needle tip affects the risk of this complication. Sixty patients participated in their study, 20 of whom received lumbar epidural block for labour analgesia, 20 received subarachnoid block (SAB) with Sprotte needle and the remaining 20 patients received SAB with a Quincke needle for caesarean delivery. The results from their study showed no patient from any of the three groups with any HL either at low

or high frequencies. The patients in the Sprotte spinal group showed a significant increased acuity in the lower frequency range (125 – 500 Hz) over the 2 –day period. In the higher frequencies between 1000 – 8000 Hz, the changes were statistically significant only at the 1000 Hz level. With the Quincke needle, increased hearing acuity was noted in all the low and high frequency ranges except at 2000 Hz. In the lumbar epidural block an increase in acuity was observed at 125 – 2000 Hz level, with no difference at 4000 or 8000 Hz. The nature of this observation (i.e. the increase in hearing acuity post-spinal anaesthesia) is difficult to explain.

Fog et al **(11)** suggest that since their investigated population was elderly and had audiometric signs of presbyacusis (i.e. HL in the high tone range). It is possible that this may predispose the patients to greater fluctuations in hearing level after spinal anaesthesia than would occur in younger patients. However, Finegold et al **(4)** suggest that the patients were slightly distracted before their initial hearing test with the excitement of the anticipated anaesthesia and operative delivery by caesarean section and therefore after delivery they were able to focus more on the hearing test. This could have led to the improved hearing and also that patients became accustomed to the test after two days of testing.

In the present study, pre-operatively the elderly patients demonstrated better hearing thresholds than younger patients in both ears. By 48 hours post-operatively, patients in the elderly group demonstrated improvement in audiometric results, even though none of the patients reported improvement in their hearing. To explain the nature of this observation, it is possible that the elderly patients were less distracted and more focused than patients in the younger age group. This explanation may have to be tested in a much larger investigation than was possible in my study.

10.CONCLUSION

This study was unable to demonstrate a reduction in hearing acuity consequent to spinal anaesthesia in the young and elderly patients. Further studies, with larger numbers of patients are needed to evaluate the clinical implication and long-term follow-up of this type of hearing loss.

The study highlights the fact that the anaesthesiologists should be aware of hearing impairment as a peri-operative complication of spinal anaesthesia. It is important for the anaesthesiologist to take an active role in preventing or minimizing the risk of significant hearing deficits. For medico-legal purposes, patients at risk of peri-operative hearing loss, this risk should be discussed with them in the pre-operative period.

11. LIMITATIONS OF THE STUDY

Caution needs to be taken before one can generalize and perhaps over-emphasize the reliability on the results from this study, for a number of reasons:

1) Audiometric testing was done by six qualified Audiometrists from the department of Audiology of the University of Limpopo (Medunsa Campus). This may have introduced an element of inter-observer bias.

2) The scope of this investigation was limited to the first two days post-operatively because of early discharge of urologic patients from the hospital (Dr George Mukhari hospital) as from day 3 onwards. Audiometric changes may be delayed for up to eight days as previously pointed out in other studies [7, 8] but some other reports [5, 6, 8, 11] have indicate that hearing loss may occur within one day after spinal anaesthesia.

3) The patency of the cochlear and vestibular aqueducts was not determined in the present study.

The patency of the bony canal determines the transmission of pressure changes to the inner ear. Sprung et al [6] had reported that in patients with anatomically obstructed cochlear aqueducts and functionally obstructed aqueducts, the CSF pressure changes are

not transmitted effectively to the perilymph and consequently affects hearing acuity.

Cosar et al [16] carried out a study investigating the effect of spinal needle diameter on HL using audiometric tests and used temporal bone CT scan, to determine the bony structure of the cochlear and vestibular aqueducts. Four out of 15 patients (26.7%) treated with a 22-gauge spinal needle demonstrated HL the day after surgery but recovered within 2 – 5 weeks. However, none of the patients treated with a 27-gauge spinal needle had statistically significant HL in either ear at any of the frequency levels. There was also no difference between the two groups in terms of the width of the vestibular and cochlear aqueducts.

4) The studies [2, 4, 6, 9, 11] referred to in this study compared different size needles and type. Due to limited resources only the size 22-gauge Quincke needle was used in this study.

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APPENDIX A

DATA COLLECTION FORM
[EVALUATION OF HEARING LOSS AFTER SPINAL ANAESTHESIA]

STUDY No		AGE		STUDY GROUP			
				YOUNG		ELDERLY	

WEIGHT (Kg)	HEIGHT (Metres)

PRE-OPERATIVE FLUID Mx	
RINGER' SOLUTION (Volume used)	

SPINAL BLOCK (Volume of Bupivacaine used)

PRE-MEDIACATION (ANXOLYSIS) [Dose: 2mg/kg of hydroxyzine (Aterax)]

ANALGESIC (post-surgery)			
YES		NO	

POST OPERATIVE DURAL PUNCTURE HEADACHE (PDPH)			
YES		NO	

[if answer is yes: RESOLUTION IN 48 HRS]

YES		NO	

	Baseline (preoperatively)		48-hours post-surgery	
	Right Ear	Left Ear	Right Ear	Left Ear
Low Frequency				
Speech Frequency				
High Frequency				

APPENDIX B

UNIVERSITY OF LIMPOPO (MEDUNSA CAMPUS) CONSENT FORM

Statement concerning participation in a Clinical Clinical Trial /Study / Project*

Name of project /Study /Trial*

……
……
……..

I have read the information on */heard the aims and objectives of* the proposed study and was provided the opportunity to ask questions and given adequate time to rethink the issue. The aim and objectives of the study are sufficiently clear to me. I have not been pressurized to participate I any way.

I understand that participation in this Clinical Trial /Study / Project* is completely voluntary and that I may withdraw from it at any time and without supplying reasons. This will have no influence on the regular treatment that holds for my condition neither will it influence the care that I receive from my regular doctor.

I know that this Trial /Study / Project* has been approved by the Research, Ethics and Publications Committee of Faculty of Medicine, University of Limpopo (Medunsa Campus) / Dr George Mukhari Hospital. I am fully aware that the results of this results of this results of this Trial /Study / Project* will be used for scientific purposes and may be published. I agree to this, provided my privacy is guaranteed.

I hereby give consent to participate I this Trial /Study / Project*.

……..	…….
Name of patient/volunteer	Signature of patient or guardian

……	……..	……..
Place	Date	Witness

Statement by the Researcher

I provided verbal and/or written* information regarding this Trial /Study / Project*. I agree to answer any future questions concerning the Trial /Study / Project* as best as I am able.
I will adhere to the approved protocol.

……	…….	……	……..
Name of Researcher	Signature	Date	Place

*Delete whatever is not applicable