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Review

Progression of Contralateral Hearing Loss in Patients with Unilateral Ear Involvement: A Scoping Review

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BACKGROUND: Progression of contralateral hearing loss following otologic and neuro-otologic surgeries is a distressing and rare complication. The aim of this study was to systematically review the suspected etiologies and audiological findings in adults who experienced contralateral hearing loss.

METHODS: PubMed/MEDLINE, PsycINFO, CINAHL, ISI Web of Science, Cochrane Library, EMBASE, and Scopus databases were searched for this scoping review. The current review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement. No limits were placed on language or year of publication.

RESULTS: Of a total of 46 studies, 43 studies met the inclusion criteria reporting contralateral hearing loss. The included studies were classified into 3 different categories: contralateral hearing loss after skull base surgeries (n = 21), contralateral hearing loss after middle ear surgeries (n = 17), and contralateral hearing loss after traumatic lesions (n = 5). The cerebrospinal fluid leakage and drill-generated noise were reported as the most reported etiology of contralateral hearing loss following skull base and middle ear surgeries, respectively. The onset of contralateral hearing loss varied from immediately to 18 months after surgery. The severity of contralateral hearing loss varied from a slight to a profound degree of hearing loss.

CONCLUSION: Our results highlighted that contralateral hearing loss should be considered following the skull base and middle ear surgeries. Furthermore, this rare complication should be noticed after traumatic lesions.

KEYWORDS: Contralateral hearing loss, review, hearing loss

INTRODUCTION

Hearing loss following otologic and neuro-otologic surgeries is a common complication and is believed to be caused by unwanted injuries to the auditory nerve, vessels, and otic capsule during the surgery.[1] However, progression of contralateral hearing loss (CoHL) following ear surgeries is a rare and distressing complication.[1]

The vestibular schwannomas are the most common tumors of the posterior fossa area, typically showing sensorineural hearing loss (SNHL) in the operated ear. However, the longitudinal assessments of the patients with vestibular schwannoma resection surgeries have also shown a mild to profound degree of CoHL in these patients.[2-7] Contralateral hearing loss has been reported in other skull base surgeries such as epidermoid cyst,[1] microvascular decompression of trigeminal neuralgia,[8,9] revision stapedectomy,[10] and mastoidectomy.[11-13] There are also some reports of CoHL, following unilateral traumatic temporal bone fractures.[14-17]

The exact mechanism of CoHL is not clear yet. Wang[7] reported a 32-year-old woman with a vestibular schwannoma tumor in the right cerebellopontine angle area. The patient developed bilateral high-pitched tinnitus, and her audiometry test result revealed a

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bilateral profound SNHL on post-operative day 5. Wang[7] suggested that compensatory endolymphatic hydrops induced by cerebrospinal fluid (CSF) loss might be regarded as a possible etiology for CoHL in this patient. Strauss et al[8] also reported a CoHL in a 52-year-old woman who was admitted for unilateral microvascular decompression in typical V3 trigeminal neuralgia on the right side. The preoperative hearing thresholds showed normal hearing in both ears, but post-operative results indicated a profound CoHL in the left ear. They proposed that dissection of the pontotrigeminal vein could be the cause of CoHL in this patient. The authors emphasized the importance of venous drainage preservation during these kinds of surgeries.

In middle-ear surgeries, the noise of drilling has been mentioned as a probable cause of the CoHL, which could lead to transient or permanent damage to the sensory hair cells.[10-13,18] Furthermore, it has been hypothesized that in patients with unilateral temporal bone fractures, severe trauma to the head will induce high-pressure waves which are directly transmitted to the cochlea and result in CoHL.[16]

Despite the numerous theories about the source of the CoHL after otologic or skull base surgeries, little convincing evidences have been published to date to support any special hypothesis. Therefore, the aim of this study was to systematically review the suspected etiologies and audiological findings, in adults who experienced CoHL.

METHODS

The protocol of this study has been registered on the International Prospective Register of Systematic Reviews (registration number, CRD42020211952). A systematic review of the literature was performed in accordance with Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines.[19]

Study Inclusion Criteria

The database searching was carried out up to April 2021 and articles written in English were eligible for evaluation. Only observational studies (cohort or case–control or cross-sectional) were eligible. Studies containing samples of patients presenting systemic or psychiatric disorders were excluded. Furthermore, commentaries, letters to editors, editorials, and conference abstracts were not eligible for evaluation.

Search Strategy

To identify relevant studies, a comprehensive search of the literature was conducted using PubMed/MEDLINE, PsycINFO, CINAHL, ISI Web of Science, Cochrane Library, EMBASE, and Scopus databases. The search keywords included were as follows: (contralateral hearing loss OR contralateral hearing disorder OR sympathetic otitis OR sympathetic labyrinthitis OR concomitant labyrinthitis OR sympathetic hearing loss OR contralateral deafness) AND (acoustic tumor OR acoustic neuroma OR skull base surgery OR vestibular schwannoma OR stapedectomy OR stapedotomy OR myringotomy OR tympanoplasty OR middle ear surgery OR mastoidectomy OR temporal bone fracture).

Selection of Studies

Two authors (M.A. and M.H.) independently screened the titles and abstracts for all of the selected relevant articles, and subsequently, they checked the full text of eligible studies against the predetermined inclusion criteria. Then, the authors extracted the data concerning the type of study, details of study methods, and patients' characteristics. Any disagreements among authors were resolved by discussion. The extracted data were arranged in an excel spreadsheet.

Data Quality Assessment

Two authors (M.A. and A.B.) independently evaluated methodological quality using the modified Newcastle–Ottawa Quality Assessment scale for non-randomized studies.

Ethics

All the experimental procedures of the present study were approved by the Institutional Research Ethics Committee (registration number: IR.AJUMS.REC.1399.672), which were in accordance with the ethical standards of the Helsinki declaration.

RESULTS

A total of 282 articles were identified at first. After the removal of duplicate records, 52 articles were assessed for eligibility (Figure 1). Finally, 43 articles were included in the review. These were divided into 3 categories: CoHL after skull base surgeries (21 articles), CoHL after middle ear surgeries (17 articles), and CoHL after traumatic lesions (5 articles).

Contralateral Hearing Loss After Skull Base Surgeries

Twenty-one studies have reported the occurrence of CoHL following skull base surgeries (Table 1). Cerebrospinal fluid leakage was the most reported etiology in these studies.[1,4,9,20,24,26-28,30] Vascular decompression and sacrification of veins during the surgery and allergic responses have also been reported as a probable etiology of CoHL in these patients. The onset of hearing loss varied from immediately to 18 months after surgery. The severity of CoHL varied from mild to profound degree of hearing loss. The majority of patients had received steroids for their hearing loss treatment.[1,3-7,20,22-24,27,29] We found that hearing thresholds have been improved (partially or completely) in a significant number of these studies.

Contralateral Hearing Loss After Middle Ear Surgeries

Of 17 articles included in this category, only 1 study was related to revision stapedectomy[10] and the other studies were related to mastoidectomy surgeries[11-13,18,32-43] (Table 2). In all of these studies, drilling noise was mentioned as the potential cause of the CoHL.[11-13,18,32-38,40-43]

Contralateral Hearing Loss After Traumatic Injuries

A total of 5 studies have reported CoHL in 7 patients who had experienced traumatic injuries. These lesions were occurred due to temporal fracture (n = 4), repeated punched (n = 1), parieto-occipital bone fracture (n = 1), or occipital extradural haemorrhage (n = 1). The main suspected etiology for CoHL after a traumatic injury was a labyrinthine concussion (Table 3).

DISCUSSION

One of the most distressing complications following neurotologic and otologic surgery is the occurrence of hearing loss in the contralateral, non-operated ear. Despite its rare prevalence, sporadic case reports document the sudden hearing loss in the contralateral ear after non-otologic and otologic surgeries. The current study aimed to

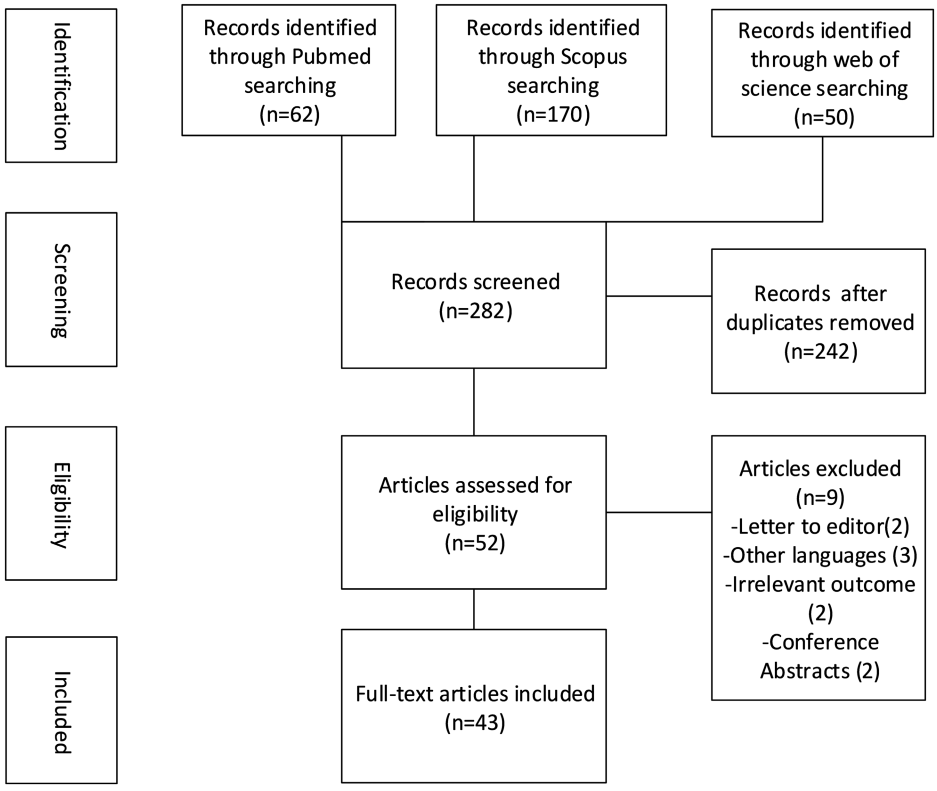

Figure 1. PRISMA flowsheet showing decision-making process of the articles included in the study. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

systematically review the suspected etiologies, audiological findings, and surgical approaches in adults who manifested CoHL.

Contralateral Hearing Loss After Skull Base Surgeries

The exact mechanism of CoHL in the skull base surgeries remains unclear. A variety of theories have been proposed to explain the cause of CoHL in these patients, including changes in inner ear fluid dynamics as a result of changes in CSF pressure, vascular compromise, increased intratympanic pressures, and allergy. Cerebrospinal fluid leakage has been suggested as one of the most important etiologies for CoHL during posterior fossa surgeries.[1,4,9,20,24,26-28,30] Normally, the pressure of CSF, perilymph, and endolymph fluid levels are equal. Any alternations in CSF pressure (such as CSF leakage) will be transmitted to the perilymph fluid via the cochlear aqueduct. After perilymph depression, a compensatory endolymph expansion may induce an endolymphatic hydrops.[26-28] The patency of the cochlear aqueduct may also cause this transformation, but it is still controversial.[27] The degree of CSF leakage is a very important factor in the severity of CoHL and the number of frequencies which may be affected following the surgery.[4,26,28] It seems that by returning the CSF and perilymphatic pressure to the normal level, the induced CoHL thresholds will be improved.[26,28,30]

Vascular compromise and occlusion of the internal auditory artery have been another explanation put forward for the phenomena of post-operative CoHL.[4,8,26,28] Occlusion of internal auditory artery may be due to thrombosis (23) or vasospasm (4). Due to long duration of the skull base surgeries, brain ischemia may lead to internal auditory artery occlusion. Therefore, blood pressure monitoring during the posterior fossa surgeries is recommended in these patients.[28] Strauss et al[8] reported a 52-year-old woman with typical trigeminal neuralgia who was admitted for unilateral microvascular decompression. On the third post-operative day, the subject complained about CoHL. Intravenous heparinization was conducted in this patient and hearing thresholds slowly recovered over a 3-month period. This finding shows the importance of venous drainage preservation during cerebellopontine angle surgeries.

In order to assess the impact of acoustic neuroma surgery on contralateral cochlear performance, Dandachli et al[45] recorded transient evoked otoacoustic emissions (TEOAEs) in 44 patients. Transient evoked otoacoustic emission responses were measured in both ears 1 day before and 1 month after surgery. At 1-month post-operation stage, 22.7% of the patients revealed a reduction, 20.5% revealed an increase in contralateral TEOAE amplitudes, while 56.8% remained stable. They also reported that in terms of surgical approach, the percentage of individuals who showed an improvement in TEOAE amplitudes in the contralateral ear was greater in the retrosigmoid (31.5%) compared to the translabyrinthine group (12%). The authors suggested that changes in the efferent fibers following the surgery could explain these adverse effects. Tos et al.[30] compared the hearing thresholds in 50 patients with acoustic schwannomas who are undergoing the translabyrinthine approach before and 3 months after tumor removal. They did not find any statistical difference between peri and post-operative pure tone audiometry thresholds. They just reported 1 patient with a significant loss (20-25 dB) in the contralateral ear. They concluded that drill noise generated during the surgery did not have any effect on CoHL.

Table 1. Contralateral Hearing Loss After Skull Base Surgeries

Author	Age (Years)	Sex	Main Cause	Onset of CoHL	Audiological Findings (CoHL)	Suspected Etiology	Hearing Improvement
Clemis et al[22]	ND	M	AN tumor removal	7 days	Mild-moderate SNHL	Unknown	Complete
	43	F	AN tumor removal	4 days	Moderate-severe SNHL	Allergic responses	Partial
	ND	M	AN tumor removal	2 months	Mild CHL	Allergic responses	Complete
de Keyser et al[23]	37	F	AN tumor removal	2 days	Sudden SNHL	IAM thrombosis	No
Harris et al[25]	30	ND	AN tumor removal	7 days	Profound SNHL	Unknown	Partial
	55	ND	AN tumor removal	31 days	Moderate-severe SNHL	Brainstem edema	Complete
	36	ND	AN tumor removal	14 days	Mild SNHL	Unknown	Partial
	34	ND	AN tumor removal	9 days	Mild SNHL	Unknown	ND
	64	ND	AN tumor removal	2.6 years	Severe SNHL	Unknown	ND
Chovanes et al[21]	35	F	AN tumor removal	2 days	Profound SNHL	Unknown/ possibly vascular	No
Nishioka et al[1]	68	F	Epidermoid removal	Immediately after surgery	Profound SNHL	CSF leakage	No
Tos et al[29]	ND	ND	AN tumor removal	3 months	Mild SNHL	ND	Partial
McDonnell et al[46]	65	M	VD for HFS	4 Days	Profound SNHL	Ototoxic reaction/vascular decompression	No
Walsh et al[29]	44	M	Meningioma removal	1 day	Profound SNHL	Unknown	No
Lusting et al[26]	56	F	AN tumor removal	4 days	Moderate SNHL	CSF leakage	Partial
	43	F	Clivus chordoma	12 Days	Moderate- profound SNHL	Unknown	Partial
	69	F	AN tumor removal	5 months	Mild-moderate HTL	Unknown	ND
	55	F	AN tumor removal	12 days	Severe SNHL	Unknown	Complete
	63	M	Epidermoid tumor	4 months	Mild-moderate SNHL	Unknown	Complete
	57	M	AN tumor removal	10 days	Mild SNHL	Unknown	No
Strauss et al[8]	52	F	VD for TGN	3 days	Severe SNHL		Partial
Colpan et al[30]	43	M	Epidermoid removal	2 Days	Severe SNHL	CSF leakage	Complete
Plans et al[4]	48	M	AN tumor removal	2 days	Severe SNHL	CSF Leakage, Vascular decompression	No
Shuto et al[27]	53	M	AN tumor removal	Immediately after surgery	Severe SNHL	CSF leakage	Partial
Bliss et al[20]	58	M	AN tumor removal	4 days	Moderate-severe SNHL	CSF leakage	Partial
Togashi et al[28]	74	M	AN tumor removal	Immediately after surgery	Severe SNHL	Unknown,	No
Deeb et al[24]	48	M	AN tumor removal	Immediately after surgery	Severe SNHL	CSF leakage, efferent system acting	Complete
Thirumala et al[9]	55.7±10.6	M to F ratio:23/62	VD for TGN, GPN, GN	ND	HTL	CSF leakage, Drill-generated noise	ND
Warade et al[6]	55	M	AN tumor removal	2 days	Profound SNHL	Unknown	Complete
arcía-Cabo et al[3]	52	F	AN tumor removal	2 Months	Moderate-severe SNHL	CSF leakage, Sympathetic cochleolabyrinthitis	No
	53	M	AN tumor removal	2 Months	Moderate SNHL	CSF leakage, Sympathetic cochleolabyrinthitis	Partial
	46	M	AN tumor removal	24 Months	Severe SNHL	CSF leakage, Sympathetic cochleolabyrinthitis	No
	46	M	AN tumor removal	12 Months	Moderate-severe SNHL	CSF leakage, Sympathetic cochleolabyrinthitis	No
Tripathi et al[5]	25	F	AN tumor removal	9 days	Severe SNHL	CSF Leakage	Complete
Wang et al[7]	32	F	AN tumor removal	1-2 days	Profound SNHL	CSF Leakage	Partial

TGN, trigeminal neuralgia; GPN, glossopharyngeal neuralgia; GN, geniculate neuralgia; HTL, high tone loss; AN, acoustic neuroma; ND, not declared; CoHL, contralateral hearing loss; HFS, hemi facial spasm; VD, vascular decompression; SNHL, sensorineural hearing loss; CSF, cerebrospinal fluid.

Table 2. Contralateral Hearing Loss After Middle Ear Surgeries

Author	Number of Patients	Surgical Approach	Audiological Findings		Suspected Etiology	Hearing Improvement
			Ipsilateral Side	Contralateral Side		
Urquuhart et al[39]	40	Mastoidectomy	ND	No changes in PTA thresholds	Drilling noise	No
Richards et al[10]	112	Stapedectomy	Moderate to severe CHL	No changes in PTA thresholds	SHL	No
Karatas et al[18]	22	Mastoidectomy, Tympanoplasty	Moderate CHL	Decreased OAE amplitudes	Drilling noise	Yes
Iranfar et al[40]	90	Mastoidectomy, Tympanoplasty	ND	Mild LTL	Drilling noise	ND
Migirov et al[35]	18	Mastoidectomy	ND	Decreased DPOAE amplitudes	Drilling noise	Yes
Paksoy et al[41]	100	Mastoidectomy, Tympanoplasty	ND	Increased hearing thresholds	Drilling noise	ND
Shenoy et al[37]	98	Mastoidectomy	ND	Decreased DPOAE amplitudes	Drilling noise	Yes
Baradaranfar et al[34]	28	Mastoidectomy, Tympanoplasty	Moderate HTL	Slight HTL	Drilling noise	Yes
Abtahi et al[42]	23	Mastoidectomy	ND	LTL, Decreased DPOAE amplitudes	Drilling noise	Yes
Patil et al[36]	80	Mastoidectomy, Tympanoplasty	ND	Mild SNHL	Drilling noise	Yes
Latheef et al[13]	50	Mastoidectomy		Absent of OAEs	Drilling noise	Yes
Badarudeen et al[32]	40	Mastoidectomy	ND	Decreased DPOAE Amplitude	Drilling noise	Yes
Jerath et al[11]	25	Mastoidectomy	ND	No changes in PTA, Decreased TEOAE amplitudes	Drilling noise	ND
Paulose et al[43]	100	Mastoidectomy	ND	Mild HTL	Drilling noise	No
Badkar et al[33]	110	Mastoidectomy	ND	Mild-moderate HTL	Drilling noise	Yes
Singh et al[38]	94	Mastoidectomy	ND	Absence of DPOAEs	Drilling noise	Yes
Kadah et al[12]	40	Mastoidectomy	ND	No changes in PTA, Decreased TEOAE amplitudes	Drilling noise	Yes

F, Female; M, Male; SNHL, sensorineural hearing loss; HTL, high tone loss; LTL, low tone loss; PTA, pure tone audiometry; ND, not declared; SHL, sympathetic hearing loss; TEOAE, transient evoked otoacoustic emission; DPOAE, distortion product otoacoustic emission.

Table 3. Contralateral Hearing Loss After Traumatic Injuries

Author	Age (Years)	Sex	Main Cause	Audiological Findings		Suspected Etiology	Hearing Improvement
				Fractured Side	Contralateral Side		
Ulug et al[16]	30	M	Longitudinal temporal bone fracture	Mixed HL	HTL	Labyrinthine concussion	No
	42	M	Mixed type temporal bone fracture	Mixed HL	HTL	Labyrinthine concussion	No
	19	M	Mixed type temporal bone fracture	Mixed HL	HTL	Labyrinthine concussion	No
Toh et al[17]	31	M	Repeated punch on the left side of the head	Normal hearing	Profound SNHL	Labyrinthine concussion	No
F. ten Cate et al[44]	23	M	Temporal bone fracture	Total deafness	Residual hearing at 500-750 Hz	Labyrinthine concussion	ND
Khairi et al[15]	31	M	Left parieto-occipital bone fracture with leftposterior fossa extradural haemorrhage	Mild HTL	Profound SNHL	Labyrinthine concussion	ND
	14	M	Right occipital extradural haemorrhage	Mild HTL	Profound SNHL	Labyrinthine concussion	ND
Sogebi et al[14]	18 to 61	13M, 19F	Unilateral physical non-exclusive ear trauma	ND	Mild mixed HL,conductive HL, and SNHL	ND	ND

F, female; M, male; HL, hearing loss; SNHL, sensorineural hearing loss; HTL, high tone loss; ND, not declared.

Contralateral hearing loss is typically manifested as SNHL. However, Clemis et al[22] reported 3 patients with translabyrinthine acoustic neuroma with conductive hearing loss after tumor resection. Two other patients showed a contralateral SNHL within 4-7 days of surgery, with complete or gradual recovery over the following 1-2 years. They suggested an allergic basis of CoHL in these patients. Thriumula et al[9] also analyzed pre-operative and post-operative hearing thresholds following microvascular decompression in patients with trigeminal neuralgia (n = 93), glossopharyngeal neuralgia (n = 6), and geniculate neuralgia (n = 8). The incidence of high-frequency hearing loss was found to be 31% in the ipsilateral ear during the surgery and 20% in the contralateral ear. Of the 47 subjects with high-frequency loss, 20 (42%) patients showed conductive hearing loss.

The degree of hearing impairment in the contralateral ear varied from mild to profound SNHL; including mild,[22,25,30] moderate,[3,20,22,25,26] moderate to severe,[3,22,25] severe,[3,4,8,20,24,26-28] and profound[6,7,21,25,29] degree of hearing loss. It has been suggested that hearing thresholds before vestibular schwannoma surgery could be regarded as an important factor to predict CoHL outcomes following tumor removal. Early et al[2] indicated that in subjects with unilateral vestibular schwannoma and baseline normal hearing thresholds on the tumor side, the progression of SNHL in the contralateral ear was not significant. However, patients with abnormally elevated hearing thresholds in the tumor-ipsilateral ear showed a significantly higher probability of reaching moderate hearing loss in the contralateral ears.

The amount of hearing function recovery following skull base surgeries varies between the partial[3,6,7,18,22,24,25,27] to complete[20,25] recovery. It has been suggested that steroid therapy might be an effective procedure for CoHL recovery in these cases.[3,6,7,20,22,24,27] Shuto et al[27] recommended that high-dose steroid and hyperbaric therapy can improve contralateral hearing disturbance after acoustic neuroma surgery. Most of the surgeons administered steroids as a common medical step after CoHL occurred. However, other drugs such as vasodilators, neurotropic drugs, vitamin C and E, antihistamine, carbogen, and hyperbaric acid were also reported.[1,6,7,22,24,27,31]

Contralateral Hearing Loss After Middle Ear Surgeries

The underlying pathophysiological mechanism causing CoHL in patients who underwent middle ear surgeries is not completely understood. It seems that drill-generated bone-conducted noise caused perioperative threshold shift in middle ear for CoHL.[11-13,18,32-38,40-43] In a study conducted by Urquuhart et al.[39] they found that there was not a significant difference between the bone conduction thresholds before and 1 day after mastoidectomy. They did not test the long-term effect on drill-generated noise, but they concluded that any changes in hearing thresholds after surgery could be the result of other factors such as the ossicular chain or labyrinthine trauma.

It has been proposed that the duration of noise exposure during middle ear surgery can influence the results. However, Badarudeen et al[31] indicated that there was no correlation between the duration of drilling and the changes in the distortion product otoacoustic emission (DPOAE) amplitudes in patients who underwent mastoidectomy. Another study conducted by Singh et al[38] on 94 patients with mastoidectomy showed that in patients with drilling time of more than 60 minutes, DPOAE amplitudes were absent in 66.6% of the patients in the immediate post-operative period, 90% of patients in 1-hour post-operative, and 100% patients on post-operative day 1. Finally, the authors suggested that using better equipment, shortening drilling time, and using more experienced surgeons can reduce the adverse effects of drill-generated noise on the auditory system.[18]

Sympathetic cochleolabyrinthitis was one of another proposed hypothesis of CoHL after some middle ear surgeries.[10] Similar to sympathetic ophthalmia, it was hypothesized that after any inner ear injury or surgical manipulation, immunocompetent cells become sensitized to sequestered inner ear antigens.[10,22,44,47] After the entrance of antigens into the systemic circulation, the immunocompetent cells migrate to the surgery field and immunogenicity of these tissues' antigens will be increased.[25,47,48]

Contralateral Hearing Loss After Traumatic Injuries

The labyrinthine concussion has been proposed as the main cause of CoHL after the traumatic lesions.[15-17] It has been hypothesized that temporal bone fracture might lead to a severe blow to the head similar to deafness from high-pressure waves caused by airborne sounds. So, it can potentially create a significant bone-conducted pressure and disrupt the organ of Corti.[17] It has been shown that labyrinthine concussion frequently occurs in longitudinal temporal fractures.[16] However, mixed types of temporal bone fracture[16] and parieto-occipital fractures have also been suggested as the probable cause of this phenomenon.[15]

High-frequency SNHL is the most common audiogram configuration in patients with labyrinthine concussion.[16,17] Sogebi et al.[14] evaluated the pattern of hearing loss that occurred in the contralateral ear of 53 patients with unilateral, physical, non-explosive ear trauma. Their findings revealed that about 72% (38/53) of patients experienced CoHL, which was mainly manifested as high-frequency hearing loss. Among these subjects with CoHL, SNHL, mixed hearing loss, and conductive hearing loss appeared in 24, 10, and 4 patients, respectively.

CONCLUSION

Our review analysis indicated that skull base and middle ear surgeries are the 2 most common causes of CoHL. The underlying mechanism of CoHL remains unclear, but some possibilities have been proposed, including CSF leakage, vascular compromise, increased intratympanic pressures, allergy, and drill-generated noise during the surgery. Contralateral hearing loss is usually manifested as SNHL, but in extremely rare patients, conductive hearing impairment has been also reported. The degree of hearing loss in the CoHL varied from mild to profound and the duration of recovery of hearing thresholds varied between partial to significant.

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