Middle Ear Dysfunction Following Laryngectomy
Dysfonctionnement de l'oreille moyenne suite à une laryngectomie

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Abstract

The purpose of this study was to examine whether middle ear dysfunction resulting in conductive hearing loss, occurs subsequent to a total laryngectomy. Six adult males were evaluated via puretone audiometry and immittance measures at three test sessions (i.e., preoperatively and postoperatively at approximately ten days and one month). The results indicated that three out of six participants developed middle ear dysfunction while two out of six exhibited a resulting conductive hearing loss. However, it was found that the abnormal middle ear function and conductive impairment had resolved in these participants by one-month postsurgery. In addition, those with middle ear dysfunction also presented with signs of edema in the face and neck area following surgical intervention. It was reasoned that those who did have this sudden conductive impairment might experience substantial communicative difficulty in many listening situations. It was suggested that an audiological monitoring program which includes pure-tone air conduction and the middle ear immittance test battery be routinely employed.

Abrégé

L'objet de cette étude était d'examiner si le dysfonctionnement de l'oreille moyenne, aboutissant à une perte d'audition d'origine tympano-ossiculaire, se produit suite à une laryngectomie totale. On a évalué six hommes adultes au moyen de mesures d'audiométrie tonale liminaire et d'immittance disposées sur trois séances (c.-à-d. préopératoire et postopératoire à environ dix jours et un mois). Les résultats ont indiqué que, chez trois participants sur six, il y a eu dysfonctionnement de l'oreille moyenne, tandis que, chez deux des six, il y a eu perte d'audition d'origine tympano-ossiculaire. Toutefois, on a constaté que l'anomalie de fonctionnement de l'oreille moyenne et la déficience tympano-ossiculaire avaient disparu lors de l'examen postopératoire de un mois. En outre, les personnes présentant un dysfonctionnement de l'oreille moyenne présentaient aussi des indices d'œdème à la figure et au cou suite à l'intervention chirurgicale. Il a été déduit que les personnes présentant une telle déficience tympano-ossiculaire soudaine pourraient avoir d'importantes difficultés de communication dans plusieurs situations d'écoute. Il a été suggéré d'utiliser régulièrement un programme de surveillance audiologique comportant l'étude du seuil auditif des sons purs en conduction aérienne ainsi que la batterie de tests d'immittance de l'oreille moyenne.

The influence of hearing loss on rehabilitative programs for persons who have undergone laryngectomy has not been a frequent area of study in the recent literature. These individuals are faced with a wide range of difficulties and problems following surgery ranging from the threat of cancer recurrence to adjusting to the significant communicative problems posed by the removal of the larynx. The presence of an existing hearing loss prior to surgical intervention or as a sequel to surgery can have a detrimental effect on the delivery of speech rehabilitation services. A loss of hearing sensitivity can also pose problems in the conveyance of critical information during the immediate postoperative period, as well as later in the rehabilitation process. Specifically, the presence of a hearing loss may impact the individual's ability to actively participate in counselling sessions related to the disease and its treatment, their ability to follow instruction for voice and speech rehabilitation, and to actively participate in a variety of communicative situations in the postoperative period.

Most patients with laryngeal carcinoma range in age from 50 to 70 years (Ramig, Bonitati, Lemke, & Horii, 1994). Consequently, this group is highly susceptible to age related sensorineural hearing loss. According to Shames, Font, and Mathews (1963) approximately 20 percent of a sample of 153 patients with laryngectomies reported that they did not have normal hearing. This finding, however, was not verified by audiometric studies. Berlin (1963) reported that 10 of 38 patients with laryngectomy had speech recognition thresholds of greater than 20 dB. Further, Berlin (1964,1965) stressed the importance of giving consideration to existing sensorineural hearing loss when initiating therapy programs. More recently, Robinette (1986) summarized the findings of several endeavors designed to establish the incidence of sensorineural hearing loss in the laryngectomy population. Over two-thirds of the 364 ears examined had hearing losses ranging from mild-to-severe.

The primary focus of this investigation involved an examination of whether middle ear pathology could prove to be a postoperative complication of laryngectomy surgery. While there have been a limited number of reports concerning the direct influence of laryngectomy on middle ear function, several investigators have noted eustachian tube and/or middle ear dysfunction as a consequence of nasopharyngeal carcinoma (Honjo, 1988; Low, Lim, Fan & Balakrishman, 1997; Myers, Beery, Rood, Bluestone, & Sigler, 1984; Su, Hsu, & Chee, 1993). Studies specifically related to laryngeal cancer, although limited, have yielded inconsistent findings. For example, Woodford and Eames (1977) found that nine of 10 patients who had laryngectomy and radical neck surgery developed bilateral otitis media with effusion (OME). The authors speculated that this OME might result from edema and/or from the patients being in a horizontal position for an extended period. Woodford and Eames increased intracranial pressure caused by damage to the internal jugular vein

Table 1
Classification of Carcinoma and Surgical Treatment Performed on each Participant

Participant	Type of Cancer	Lymph Node Involvement	Type Of Surgery	Location Of Neck Dissection
1	Squamous Cell	Yes	Total Laryngectomy	Right Functional and Left Radical
2	Squamous Cell	Yes	Total Laryngectomy	Right Radical
3	Squamous Cell	No	Total Laryngectomy	None
4	Squamous Cell	Yes	Total Laryngectomy	Bilateral Radical
5	Squamous Cell	Yes	Total Laryngectomy	Left Functional
6	Squamous Cell	Yes	Pharyngo-Laryngectomy	Left Modified Radical and Right Supraradical

during surgery was another possibility. Regardless of the underlying cause of such changes in middle ear function, such a change and its effect on hearing is an important and essential consideration relative to the rehabilitation process. Thus, the purpose of the present report was to examine the extent of middle ear dysfunction following laryngectomy. Obviously, if middle ear pathology is a frequent observation following laryngectomy then middle ear immittance measures should be a part of the pre- and postsurgical evaluation and speech-language pathologists and audiologists should be aware of its effects on the delivery of rehabilitation programs.

Method

Participants

Six adult males, ranging in age from 46 to 66 years (M = 60 years, SD = 7.1), who underwent a total laryngectomy along with neck dissection for treatment of laryngeal cancer participated. A summary of the nature of the carcinoma for each patient and type of surgery performed is presented in Table 1.

Apparatus

All audiometric testing was performed in a sound enclosure meeting criteria for permissible ambient noise levels (American National Standards Institute, 1991). Pure-tone signals in octave steps from 250 to 8000 Hz generated by a clinical audiometer (Grason-Stadler Model GSI 61) calibrated to meet American National Standards Institute standards (American National Standards Institute, 1996) were employed to assess audiometric thresholds. Middle ear function was conducted using an Intra Acoustics immittance device (Model AZ26), calibrated according to American National Standards Institute standards (American National Standards Institute, 1996).

Procedure

Informed consent and a case history were obtained from each participant prior to audiological testing. Audiometric assessment was conducted on three occasions. Preoperative testing occurred the day before the scheduled surgery. A postoperative second test session took place between seven to ten days following surgery. Complete audiometric testing could not be carried out at the first postoperative session for Participant 4 due to the fatigue. Therefore, he also was evaluated at approximately two weeks postsurgery. A second and final postoperative session was undertaken approximately at one month in conjunction with postsurgical medical follow-up.

Audiometric assessment included otoscopy, assessment of audiometric thresholds, and middle ear analysis. An otoscopic visual inspection of the ear and tympanic membrane was performed at the beginning of each testing session to ensure that the ear canal was free of major debris and that the tympanic membrane was visible. Auditory thresholds were obtained at 250, 500, 1000, 2000, 4000 and 8000 Hz with the threshold determination procedure recommended by the American Speech-Language-Hearing Association (1978). Air pressure was swept in a positive to negative direction (i.e., 200 to –400 daPa) at a rate of 150 daPa/s during middle ear function assessment. Contralateral acoustic reflexes were elicited at 500, 1000 and 2000 Hz. A biological calibration was performed on all equipment prior to each test session.

A change in hearing sensitivity was determined by a decrease in hearing thresholds exceeding the 95% confidence levels representing critical differences in test-retest auditory thresholds from preoperative to postoperative testing (Stuart, Stenstrom, Tompkins, & Vandenhoff, 1991). The immittance results were classified as normal if compensated static acoustic admittance values were between 0.3 and 1.7 mmhos (Wiley, Cruickshanks, Nondahl, Tweed, Klein, & Klein 1996) and with acoustic reflexes present in pattern consistent with the degree of sensorineural hearing loss present.

Results

Participants' preoperative and postoperative compensated static acoustic admittance acoustic reflex thresholds, and hearing thresholds are presented in Tables 2, 3, and 4, respectively. The results of this study showed that three of the six participants exhibited changes in auditory function consistent with middle ear dysfunction subsequent to laryngectomy. Participants 1 and 2 evidenced a reduction in compensated static acoustic admittance (see Table 2). Participant 4 displayed an absence of acoustic reflexes following surgery. Participants 1 and 2 also displayed significant reduction in auditory thresholds at postoperative testing with the former displaying the greatest reduction in hearing sensitivity. Participant 1 also presented with bilateral involvement while Participant 2 presented with unilateral involvement.

At the second postoperative evaluation Participant 1 presented with bilateral myringotomy tubes which were inserted at approximately three weeks postlaryngectomy. The results of immittance testing indicated large physical ear canal volumes of 3.38ml in the left ear and 3.88ml in the right ear, consistent with patent ventilating tubes. It was also found that hearing sensitivity had improved from the first postoperative test, but still remained slightly decreased from 250 to 1000Hz bilaterally as compared to the preoperative evaluation.

During the second postoperative assessment, Participate 2's audiometric hearing thresholds had improved to where they had been preoperatively. Also, compensated static acoustic admittance values were within normal limits bilaterally (Wiley et al., 1996). Left contralateral acoustic reflexes were present at 500, 1000, and 2000 at 90, 95, 90 dB respectively. Right contralateral reflexes were present from 500 to 2000Hz at 110, 100 and 80dB respectively.

Discussion

The primary focus of this clinical investigation focused on determining if middle ear pathology was present and to assess its extent following total laryngectomy for treatment of laryngeal cancer. This study has shown that middle ear dysfunction and conductive hearing loss may occur in following total laryngectomy in some patients, however, not in any predictable pattern. The results also showed that the abnormal middle ear function had a time course of less than one month postsurgery. However, it must be noted that in one case middle ear pathology was resolved medically with bilateral myringotomy tubes by the time of one-month postoperative evaluation.

It seems that four main interrelated factors were present when conductive hearing loss and/or middle ear dysfunction was found with these patients following laryngectomy. These factors were location of the tumor, type of surgical treatment, degree of edema postoperatively and mobility of the participants. In the three participants where dysfunction of the middle ear was found, it was observed that this dysfunction coincided with significant edema in the face and neck area ipsilateral to the lesion and subsequent surgery. This can be illustrated with Participant 1 where a total laryngectomy along with a bilateral neck dissection had been performed. The resulting middle ear dysfunction and conductive hearing loss was bilateral and significant observable edema was present. It also was noted that the patient was not mobile and remained lying in a supine position for an extended period. Also, with Participant 2 the carcinoma had invaded the lymph nodes and a right radical neck dissection was performed. Upon evaluation, middle ear dysfunction and conductive hearing loss was present on the right side. Therefore, it could be inferred that the resulting inflammation of the mucosal lining of the eustachian and middle ear contributed to the middle ear dysfunction and resulting conductive hearing loss in these participants. This resulting sudden conductive impairment in addition to existing sensorineural hearing loss may create more difficult listening situations when communicating with family members, medical professionals as well as with the speech-language pathologist during a critical time.

This finding suggests that two areas of clinical concern must be considered in regard to clinical interactions with such individuals. Given that those individuals diagnosed with laryngeal cancer are usually in their sixth to seventh decades of life (Ramig et al., 1994), the potential for sensorineural hearing loss is certainly increased. Such hearing impairment clearly has the potential to influence communication. As such, hearing loss may impact counselling and information provision in the preoperative period of patient care. However, based on the present data, concerns about conductive hearing loss as a postsurgical sequelae are also raised. Consequently, individuals who undergo total laryngectomy may face substantial difficulties in understanding information about surgery, postoperative care, and voice and speech rehabilitation because of an existing, presurgical degree of hearing loss which is further complicated by postsurgical changes in the conductive component of hearing. This problem would appear to also have implications for the effective instruction in the use of alaryngeal speech and the individual's ability to use such alaryngeal method(s) in a communicative environment (Doyle, 1994).

In two participants, conductive hearing loss occurred in addition to the existing sensorineural hearing loss following surgery. One may

Table 2
Participants' Preoperative and First Postoperative Compensated Static Acoustic Admittance (ml) Measures as a Function of Ear

		Compensated Static Acoustic Admittance (mmhos)	
		Ear	
Participant		Left	Right
1	Preoperative	.36	.40
	Postoperative	.06*	.05
2	Preoperative	1.13	.99
	Postoperative	.72	.22*
3	Preoperative	1.12	.93
	Postoperative	1.01	.74
4	Preoperative	.80	.65
	Postoperative	.64	.54
5	Preoperative	.64	.40
	Postoperative	.49	.32
6	Preoperative	.42	.58
	Postoperative	.36	.43

Note: * indicates reduced compensated static acoustic admittance as per Wiley et al. (1996)

surmise that this may create additional listening difficulties postoperatively. Therefore, it is suggested that patients be assessed audiologically on a routine basis following laryngectomy. Such monitoring should include similar audiologic monitoring procedures as employed in this study. For example, testing could occur preoperatively and then one-week and again at one-month postoperative. The evaluation would include pure-tone air and bone conduction testing, as well as the full immittance battery. Patient education would naturally occur during counselling following testing where indicated. Abnormal hearing sensitivity results would be useful to both the medical and rehabilitation professionals in that they would become aware of their patient's temporary conductive hearing impairment and adapt their communication strategies accordingly.

In conclusion, laryngeal carcinoma and its treatment with total laryngectomy will result in a loss of one's ability to use natural spoken language for communication. The presence of existing hearing loss and the potential for additional hearing loss as a result of surgery has significant clinical implications. Therefore, it then becomes a question of quality of life in that both medical and health care professionals should do their best to preserve function and manage deficits, including the patient's hearing sensitivity and resultant communicative deficit. As stated by Myers et al. (1994), attention "to such small details when these types of massive ablative surgery are necessary will help to improve the patient's quality of life in the postoperative period." While the results of this study are based on a small sample size the interaction of total laryngectomy and associated neck dissection would seem to have increased potential for influencing hearing status. The present findings provide an initial database from which additional and larger-scale research could be undertaken in an effort to further elucidate hearing changes in those individuals diagnosed and treated for laryngeal cancer. Continued efforts of this nature may assist in determining if in fact any predictable pattern exists with regard to middle ear function and conductive hearing impairment in this population. Such information would appear to be of value to the patient, members of their family, as well as to those professionals who provide pre- and postlaryngectomy care to these individuals.

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Table 3
Participants' Preoperative and First Postoperative Acoustic Reflex Threshold Measures as A Function of Frequency and Ear

		Frequency (Hz)		
Participant	Ear	500	1000	2000
1	Left Preoperative Postoperative	 >110 >110	 >110 >110	 >110 >110
	Right Preoperative Postoperative	 100 >110	 95 >110	 85 >110
2	Left Preoperative Postoperative	 100 >110	 80 >110	 110 >110
	Right Preoperative Postoperative	 100 >110	 95 >110	 110 >110
3	Left Preoperative Postoperative	 110 100	 110 95	 110 95
	Right Preoperative Postoperative	 110 105	 110 95	 >110 105
4	Left Preoperative Postoperative	 95 >110	 90 >110	 90 >110
	Right Preoperative Postoperative	 100 >110	 95 >110	 95 >110
5	Left Preoperative Postoperative	 85 85	 90 90	 85 85
	Right Preoperative Postoperative	 95 90	 95 90	 95 95
6	Left Preoperative Postoperative	 80 80	 85 95	 80 90
	Right Preoperative Postoperative	 80 80	 80 85	 80 85

Table 4
Participants' Preoperative and First Postoperative Hearing Threshold Measures as a Function of Frequency and Ear

		Frequency (Hz)					
Participant	Ear	250	500	1000	2000	4000	8000
1	Left Preoperative Postoperative	20 35*	25 40*	25 45*	30 35	45 40	40 35
	Right Preoperative Postoperative	25 30*	20 30*	15 40*	25 30	45 50	25 30
2	Left Preoperative Postoperative	25 25	20 20	10 10	25 25	55 50	65 65
	Right Preoperative Postoperative	10 25*	10 20*	10 20*	10 25*	35 40	40 45
3	Left Preoperative Postoperative	20 15	20 25	20 25	50 50	60 45	35 15
	Right Preoperative Postoperative	25 15	20 25	25 25	35 40	45 30	20 15
4	Left Preoperative Postoperative	15 10	15 15	20 20	25 30	60 55	60 50
	Right Preoperative Postoperative	20 20	15 20	25 25	45 35	70 55	70 60
5	Left Preoperative Postoperative	20 25	15 10	10 5	5 5	5 5	20 5
	Right Preoperative Postoperative	20 25	15 15	10 10	5 5	10 15	5 10
6	Left Preoperative Postoperative	20 15	15 15	15 15	35 35	45 45	55 55
	Right Preoperative Postoperative	20 15	20 20	35 40	35 40	45 45	65 65

Note: * indicates postoperative thresholds exceeding the 95% confidence levels for critical differences in test-retest auditory thresholds from preoperative testing.

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