EFFECTS OF RADIATION ON HEARING IN PATIENTS WITH MALIGNANCIES OF HEAD AND NECK

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ABSTRACT

Patients with normal hearing at the start of radiation were tested for hearing during (30 GY) and at the end of radiation therapy (45-60 GY) in order to determine if there was any alteration in their pure tone hearing thresholds. A significant increase in the hearing threshold was found at high frequencies at the end of therapy. At the end of the course of radiation, clinical findings suggestive of middle ear changes due to radiation were seen in 33% of the ears.

Patients whose ears are included in the field of radiation may have to be forewarned to expect a loss in their acuity of hearing, especially those whose professional life may depend on it.

Keywords: Head and Neck Neoplasms, Hearing Loss, Radiation injuries, Radiation effects.

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INTRODUCTION

Radiation plays an important part in the treatment of malignancies of the head and neck region. While the purpose of radiation is to destroy tumour cells, it also destroys normal cells within the volume irradiated. Since the ear is often included in the irradiated volume when treating head and neck malignancies, it may be damaged resulting in disturbance of its function.

A review of scientific literature revealed a paucity of prospective clinical studies on the effects of radiation on hearing. Hence a prospective study was designed and conducted in order to determine whether radiation affected the hearing of patients undergoing radiation therapy for tumours of the head and neck region.

MATERIALS AND METHODS

Patients with head and neck malignancies, attending the ENT and the Radiation Therapy Departments of Christian Medical College and Hospital at Vellore in 1988 were screened for the study if the fields of irradiation for their treatment included the ear. Only patients whose auditory canals were in the radiation field were included in the study. Each ear was chosen as a unit for the study.

The patients included for the study underwent an initial clinical examination followed by an audiological examination before radiation therapy (Pre-RT). Patients who had an abnormal appearance of the ear or the tympanic membrane, a discharging ear or who received drugs known to be toxic to the cochlea or had abnormal pure tone hearing thresholds prior to RT were excluded from the study.

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Clinical and audiological examinations were repeated during radiation therapy (30 GY) and at the end of RT (Post RT, 45 GY to 60 GY).

Audiological examination included pure tone audiogram (PTA) and loudness discomfort level (LDL). All auditory assessments were carried out by an audiologist using an Arphi Clinical Diagnostic Audiometer, model 700, Mark 4 and a standardized technique. Ten percent of the audiogram were cross-checked by the investigator randomly in order to validate the findings of the audiologist. The average PTA thresholds for air conduction (AC) in low frequencies (500, 1000, 2000 Hz) and high frequencies (4000, 6000, 8000 Hz) were recorded at each visit. The average change in air conduction thresholds in high and low frequencies, and bone conduction thresholds (500 to 4000 Hz) before RT were compared with the values obtained during and after RT. Whenever there was a difference in the mean hearing threshold, a paired t-test was done.

The machine used for radiation therapy was Cobalt 60 Tele-therapy, at a source to skin distance of 80 cm. Patients received a daily tumour dose of 2 GY using one fraction a day for 5 days a week. The total tumour dose varied with disease and volume treated and ranged from 30 to 60 GY in 3 to 4 weeks. The exact dose to the cochlea included in the field of radiation was calculated by a Treatment planning system with THE PACK Software.

RESULTS

Fifty-seven patients with head and neck malignancies who attended the hospital in 1988, had radiation therapy with their ear(s) in the field of radiation. Thirty-two of these patients had normal hearing in one or both ears. There were a total of 52 normal ears among these patients which fulfilled the selection criteria before radiation. Five patients dropped out of the study before the end of RT. Forty-one of the normal ears (79%) belonged to patients with intracranial tumours like astrocytomas grade 1, 2 and 3, pituitary adenomas, oligodendrogliomas, ependymomas and mixed gliomas. In the remaining patients the other malignancies were nasopharyngeal carcinoma, maxillary carcinoma, parotid tumours and lacrymal gland tumours.

Table I shows the types of malignancies, the prescribed tumour dose and average dose to the ear included in the radiation field and the fields irradiated for each type of malignancy. The tumour dose ranged from 30 to 60 GY administered over a 3 to 6-week period.

Table II shows the age and sex distribution of the patients whose ears were studied. There were 18 males and 14 females, most of whom were between 21 and 40 years.

Table I - The type of malignancy, dose of radiation administered and field of radiation used

Type of Malignancy	Tumour dose in GYs	Av. Radiation dose to the ear(s) in Gy included in the field of radiation	Field of radiation
Intracranial tumours	45	44.5	Parallel opposed lateral fields
Carcinoma nasopharynx	45	45.5	Parallel opposed lateral and Anterior boost fields.
Carcinoma maxilla	60	61.0	Perpendicular Wedge Field
Parotid tumours	60	58.2	Angled Wedge Field
Carcinoma lacrimal gland	60	61.0	Perpendicular Wedge Field

Table II - The age and sex distribution of patients who fulfilled the inclusion criteria before the start of radiation therapy

Age in Years	Male	Percent	Female	Percent	Total	Percent
0-10	2	11.1	1	7.1	3	9.4
11-20	2	11.1	3	21.4	5	15.6
21-30	6	33.3	2	14.3	8	25.0
31-40	4	22.2	5	35.8	9	28.1
41-50	3	16.7	3	21.4	6	18.8
More than 50	1	5.6	0	-	1	3.1
Total	18	100	14	100	32	100

During the course of radiation therapy in 17 of the 52 ears (33%) the patients developed clinical complaints related to the irradiated ear or had clinical signs which were not present before RT. Congestion and retraction of the tympanic membrane was the commonest finding (17 ears). In these 17 ears, 9 had desquamation of the external canal, 8 complained of fullness and blocked feeling of the ear and 5 complained of pain in the ear. None of the cases was severe enough to discontinue or postpone radiation therapy. When tested at high frequencies, the hearing thresholds of 19 ears increased during RT and by the end of RT, the threshold had increased in 23 ears. When tested at low frequencies the hearing thresholds in 14 and 20 ears increased during and at the end of RT respectively.

Table III shows the average air conduction test values at high frequency. It also shows the changes in the mean threshold of hearing with RT, the results of paired t-test and the 2 tailed probability of observing such a value by chance. The hearing threshold had increased significantly with RT when compared to the pre-RT baseline reading. This increase was statistically significant at the 5% level.

At low frequencies an increase in the hearing threshold was seen after RT when compared to the pre RT baseline. This increase was not statistically significant (Table IV).

Table V shows the results of bone conduction tests before, during and after RT. At the end of RT, there was an increase in the hearing threshold, but this was marginal.

DISCUSSION

This study showed a significant hearing loss at high frequency in the immediate post radiation period. There was no significant difference in hearing loss during RT.

Table III - Mean air conduction values in the ears tested at high frequency before RT, during RT and at end of RT, the difference in their mean values, t value and 2 tailed probability.

	Number of ears	Mean threshold (dB)	Mean Difference	t Value	2 tailed probability
Before RT	52	14.15			
During RT (30 Gy)	52	14.98	-0.826	-0.79	0.43
Before RT	47	14.27			
End of RT (45 to 60 Gy)	47	17.44	-3.17	-2.13	0.039*
During RT (30 Gy)	47	15.38			
End of RT (45 to 60 Gy)	47	17.44	-2.06	-1.81	0.077

** Statistically significant at 5% level*

Table IV - Mean air conduction values in the ears tested at low frequency before RT, during RT and at end of RT, the difference in their mean values, t value and 2 tailed probability.

	Number of ears	Mean threshold (dB)	Mean Difference	t Value	2 tailed probability
Before RT	52	12.51			
During RT At 30 Gy	52	11.63	0.88	1.23	0.22
Before RT	47	12.48			
End of RT (45 to 60 Gy)	47	12.80	-0.31	-0.29	0.77
During RT (30 Gy)	47	11.97			
End of RT (45 to 60 Gy)	47	12.80	-0.82	-0.90	0.37

Table V - Mean bone conduction values in the normal ears that were tested prior to RT, during RT, at the end of RT, differences between their mean value, t value and the 2 - tailed probability.

	Number of ears	Mean	Mean Difference	t Value	2 tailed probability
Before RT	52	4.74			
During RT	52	4.58	0.15	0.25	0.80
Before RT	47	4.63			
End of RT	47	4.68	-0.04	-0.07	0.94
During RT	47	4.54			
End of RT	47	4.71	-0.17	-0.23	0.81

However, the number of ears that had become worse during RT increased further at the end of RT. This suggests a trend in the increase of the threshold of hearing from as early as 3 weeks after the start of RT. There was a mean difference of 3.17 dB in the mean hearing threshold between the start and the end of RT. Other studies have shown a worsening of hearing as well[1]. Maximum loss of hearing was found to be at

4000 Hz[2]. Among the 52 ears in the present study a trend towards loss of hearing at low frequencies is seen but this is not statistically significant (p value = 0.07). Some patients showed an improvement in hearing in this study although overall the group showed a loss of hearing. This finding has also been reported by other authors[1,2].

Clinical complaints and clinical signs related to the ear were observed in 33% of the ears. Lederman[3] had reported that 50% of the cases in his series developed symptoms related to the ear after the start of irradiation of the ear are secondary to inflammation of the middle ear and the eustachian tube resulting in serous otitis media[4]. In the present study, the retracted tympanic membrane (TM) and the congested TM may be suggestive of serous otitis media. However, the pathology was not confirmed by any other objective method.

The patients who developed abnormal hearing thresholds with radiation were all 42 years of age or more except for one who was 19 years of age. Many older patients had been excluded from the study earlier because they had abnormal hearing at the start. It is debatable whether the hearing loss is accelerated after RT depending on the age of the patient. A larger series with adequate representation from the different age groups would be essential to prove or disprove this observation.

Degeneration of stria vascularis and atrophy of spiral ligament and basilar membrane in irradiated human temporal bones have been demonstrated[5]. However, this could have been secondary to osteoradionecrosis. The destruction of organ of Corti and atrophy of the eighth nerve after radiation to the temporal bone have also been demonstrated along with a gradual loss of hearing developing over months to years after exposure[6,7]. Exposure of inner ear of chincilla to fractionated doses of ionizing radiation has been shown to result in a delayed degeneration of sensory and supporting cells in organ of Corti as well as loss of the eighth nerve fibres. The damage increased with increasing dose of radiation[8].

Since the present study did not follow-up patients over a longer period of time the long term effects of radiation on hearing could not be established. However, there is sufficient evidence to show that the acuity of hearing in some patients is reduced with radiation. Efforts to shield the ear during radiation should be devised. Patients should be forewarned to expect a lowered acuity of hearing with RT especially older patients and those whose profession may depend on their acuity of hearing. As suggested by O'Neill[9] all patients receiving radiation therapy which will include portions of the temporal bone, should have pre-treatment and post-treatment audiometric evaluation and tympanograms.

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