

Association Between Eustachian Tube Obliteration Grade and Audiologic Outcomes in Patients with Nasopharyngeal Carcinoma

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Abstract

Nasopharyngeal carcinoma (NPC) frequently involves the fossa of Rosenmüller and surrounding structures adjacent to the pharyngeal orifice of the Eustachian tube (ET), potentially causing ET dysfunction, middle ear effusion, and conductive hearing impairment. However, the association between radiologic ET obliteration severity and audiologic outcomes remains insufficiently explored. To evaluate the association between CT-based ET obliteration grade and audiologic outcomes in patients with NPC. A cross-sectional analytic observational study was conducted involving 26 patients that histopathologically confirmed NPC. ET obliteration was assessed using contrast-enhanced head and neck computed tomography (CT). Audiologic outcomes were evaluated using pure tone audiometry, average air-bone gap (ABG), and tympanometry. Correlation analyses were performed using Spearman's rho test. The mean age of participants was 46.46 ± 12.34 years, with male predominance (57.7%). Grade 3 ET obliteration was the most common finding (42.3%), while type B tympanogram predominated (88.5%). Significant positive correlations were identified between ET obliteration grade and degree of hearing loss ($r = 0.621$; $p < 0.001$), as well as average ABG ($r = 0.411$; $p = 0.037$). No significant association was observed between ET obliteration and tympanogram type ($p > 0.515$). Tumor stage demonstrated a positive correlation with ET obliteration grade ($r = 0.485$; $p = 0.012$). Tumor volume was significantly associated with ET obliteration grade ($r = 0.474$; $p = 0.014$) and hearing loss severity ($r = 0.537$; $p = 0.005$). Greater ET obliteration severity on CT imaging was associated with worse audiologic outcomes in NPC patients. Radiologic assessment of ET obliteration may serve as a useful indicator of middle ear dysfunction and hearing impairment in NPC.

Keywords: Nasopharyngeal carcinoma; Eustachian tube dysfunction; Hearing loss; Tympanometry; Computed tomography.

Abbreviations: ABG (Air-Bone Gap), CT (Computed Tomography), ET (Eustachian Tube), ETD (Eustachian Tube Dysfunction), NPC (Nasopharyngeal Carcinoma), OME (Otitis Media with Effusion), PTA (Pure Tone Audiometry)

INTRODUCTION

Nasopharyngeal carcinoma (NPC) is a malignant epithelial tumor arising from the nasopharyngeal mucosa and remains one of the most prevalent head and neck malignancies in Southeast Asia, including Indonesia (Chen et al., 2019; Sung et al., 2021). The disease frequently presents at an advanced stage because of its deep anatomical location and nonspecific early manifestations. The fossa of Rosenmüller, the most common site of NPC origin, is anatomically adjacent to the torus tubarius and pharyngeal orifice of the Eustachian tube (ET), predisposing patients to ET

dysfunction and middle ear pathology (Lee et al., 2019; Low & Fong, 2020).

Tumor extension toward the ET may produce mechanical obstruction, interfere with the tensor veli palatini and levator veli palatini muscles, and impair middle ear ventilation. Persistent ET dysfunction may subsequently result in negative middle ear pressure, otitis media with effusion (OME), tympanic membrane compliance abnormalities, and conductive hearing loss (Bluestone & Swartz, 2018). Clinically, these alterations can be detected through pure tone audiometry and tympanometry.

Computed tomography (CT) plays a major role in evaluating local tumor extension and anatomical

involvement of adjacent structures. CT imaging also allows objective assessment of ET obliteration severity, which may correlate with functional audiologic impairment. Although several studies have discussed otologic manifestations of NPC, limited data specifically evaluate the relationship between CT-based ET obliteration severity and audiologic outcomes.

This study aimed to evaluate the association between ET obliteration grade and audiologic outcomes in patients with NPC.

MATERIALS AND METHODS

Study Design and Participants

This cross-sectional analytic observational study was conducted in patients diagnosed with NPC at a tertiary referral hospital. A total of 40 patients were initially screened; however, only 26 patients fulfilled the inclusion criteria and were included in the final analysis. Patients with incomplete radiologic data, unavailable DICOM CT scans, or inadequate clinical condition preventing audiologic examination were excluded.

Inclusion and Exclusion Criteria

Inclusion criteria consisted of histopathologically confirmed NPC patients who underwent contrast-enhanced head and neck CT scan and complete audiologic evaluation. Exclusion criteria included previous ear surgery, chronic suppurative otitis media, congenital hearing disorders, incomplete radiologic data, and inability to complete audiologic testing.

Radiologic Evaluation

Contrast-enhanced head and neck CT scans were reviewed to assess ET obliteration grade. Tumor location, tumor stage, and tumor volume were also evaluated. ET obliteration severity was categorized

according to the degree of pharyngeal orifice obstruction observed on CT imaging.

Audiologic Evaluation

Audiologic assessment consisted of pure tone audiometry and tympanometry. Hearing loss severity was classified according to pure tone average (PTA). Air-bone gap (ABG) was calculated to assess conductive hearing impairment. Tympanometric findings were categorized as type A, B, or C.

Data Analysis

Statistical analyses were performed using SPSS software. Normality testing was conducted using the Shapiro-Wilk test. Correlation analyses between ET obliteration grade and audiologic parameters were evaluated using Spearman's rho correlation test. Statistical significance was defined as $p < 0.05$.

Ethical Consideration

This study was approved by the institutional ethics committee. All procedures were conducted according to the Declaration of Helsinki.

RESULTS AND DISCUSSION

Results

Baseline Characteristics

A total of 26 patients with NPC were included. Male patients predominated (57.7%), with a mean age of 46.46 ± 12.34 years. Neck mass was the most common presenting symptom (42.3%). Right-sided tumor location was identified in 73.1% of subjects. Type B tympanogram was the predominant tympanometric finding (88.5%), while T2 stage represented the largest proportion of tumor stage (53.8%). Grade 3 ET obliteration was the most common radiologic finding (42.3%).

Table 1. Baseline Characteristics of Subjects.

Variable (n=26)	n (%)	Average $\pm$ SD	Median (Min-Max)
Sex			
Male	15 (57.7)		
Female	11 (42.3)		
Age (years)		46.46 ± 12.34	48 (22 - 66)
Main Symptoms			
Nasal	9 (34.6)		
Otologic	6 (23.1)		
Neck mass	11 (42.3)		
Tumor location			
Right	19 (73.1)		
Left	7 (26.9)		
Degree of hearing loss			
Normal			
Mild	6 (23.1)		
Moderate	7 (26.9)		
Moderately severe	5 (15.4)		
Severe	5 (15.4)		

Variable (n=26)	n (%)	Average $\pm$ SD	Median (Min-Max)
Profound	2 (7.7)		
Average ABG (dB)	1 (3.8)		
Tumor Volume (cm ³)		21.10 $\pm$ 11.49	21.9 (5 - 40)
Tympanogram type		54.01 $\pm$ 50.63	47 (1 - 218)
A	2 (7.7)		
B	23 (88.5)		
C	1 (3.8)		
Primary tumor stage			
T1	3 (11.5)		
T2	14 (53.8)		
T3	3 (11.5)		
T4	6 (23.1)		
ET obliteration grade			
Grade 0	6 (23.1)		
Grade 1	0		
Grade 2	9 (34.6)		
Grade 3	11 (42.3)		

Association Between ET Obliteration and Audiologic Outcomes

A statistically significant positive correlation was observed between ET obliteration grade and degree of hearing loss ($r = 0.621$; $p < 0.001$). Increased ET obliteration severity was also associated with larger average ABG values ($r = 0.411$; $p = 0.037$). However, no significant association was identified between ET obliteration grade and tympanogram type ($p > 0.515$).

Table 2. Correlation Between ET Obliteration Grade and Audiologic Outcomes.

Variables	r	p-value
Degree of hearing loss	0.621	< 0.001
Average ABG	0.411	0.037
Tympanogram type	-	> 0.515

Association Between Tumor Burden and Audiologic Parameters

Tumor stage demonstrated a significant positive correlation with ET obliteration grade ($r = 0.485$; $p = 0.012$). Tumor volume distribution was non-normal according to the Shapiro-Wilk test. Tumor volume was positively correlated with ET obliteration grade ($r = 0.474$; $p = 0.014$) and degree of hearing loss ($r = 0.537$; $p = 0.005$). The association between tumor volume and average ABG did not reach statistical significance ($r = 0.356$; $p = 0.074$).

Table 3. Correlation Between Tumor Burden and Audiologic Parameters.

Variables	r	p-value
Tumor stage vs ET obliteration	0.485	0.012
Tumor volume vs ET obliteration	0.474	0.014
Tumor volume vs hearing loss	0.537	0.005
Tumor volume vs ABG	0.356	0.074

Discussion

This study demonstrated significant associations between CT-based Eustachian tube (ET) obliteration severity and audiologic outcomes in patients with nasopharyngeal carcinoma (NPC), consistent with previous reports describing ET dysfunction as a major contributor to conductive hearing impairment in NPC patients (Cheng et al., 2019; Ho et al., 2018). Greater ET obliteration was associated with more severe hearing loss and larger air-bone gap (ABG) values, indicating that progressive obstruction of the ET contributes substantially to middle ear dysfunction and conductive hearing impairment.

The predominance of type B tympanogram findings reflects impaired middle ear ventilation and middle ear effusion secondary to ET dysfunction. Anatomically, NPC commonly arises in the fossa of Rosenmüller adjacent to the torus tubarius, allowing tumor extension to mechanically obstruct the ET orifice and interfere with active ET opening mechanisms. Persistent obstruction may lead to negative middle ear pressure, fluid accumulation, and reduced ossicular mobility.

Tumor burden also showed important clinical associations. Larger tumor volume and higher tumor stage were significantly correlated with greater ET obliteration severity and worse hearing loss. These findings suggest that increasing local tumor extension may produce more extensive compression and infiltration around the ET region, thereby worsening auditory dysfunction.

No significant association was identified between ET obliteration grade and tympanogram type. This finding may be related to the predominance of type B tympanograms in the study population, limiting variability for statistical comparison.

This study highlights the potential role of CT evaluation of ET involvement as an indicator of audiologic impairment in NPC patients. Nevertheless, several limitations should be acknowledged, including the cross-sectional design and relatively small sample

size. Further longitudinal studies with larger populations are necessary to clarify the prognostic significance of ET obliteration in NPC-associated hearing impairment.

CONCLUSIONS

CT-based ET obliteration severity was significantly associated with hearing loss severity and average ABG in patients with NPC. Greater tumor burden was also associated with increased ET obliteration and worse audiologic outcomes. These findings suggest that radiologic evaluation of ET involvement may play an important role in assessing middle ear dysfunction and hearing impairment in NPC patients.

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