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Patterns of cervical lymph node involvement in laryngeal carcinoma: Clinical, anatomical, and TNM-based insights

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Abstract

Introduction: Laryngeal cancer is a major global health issue. It shows different patterns of cervical lymph node spread depending on the tumor's location and characteristics. Understanding these patterns is important for planning treatment and assessing prognosis. This study analyzed cervical lymph node involvement in patients with laryngeal cancer, focusing on its relationship with anatomical locations and TNM staging.

Methods: This cross-sectional observational study included 100 patients with laryngeal cancer treated at Dhaka Medical College Hospital from March to September 2015. Data were collected through structured interviews, physical examinations, indirect laryngoscopy, and histopathological analysis. We used the Statistical Package for the Social Sciences version 26 for statistical analysis, which included descriptive statistics, Pearson correlation analysis, Chi-square tests, and multivariate logistic regression to find predictors of lymph node involvement.

Results: Lymph node involvement was found in 100% of patients. Supraglottic tumors had a much higher involvement rate at 95%, compared to glottic tumors at 5%. Level III lymph nodes were the most affected, at 50%, followed by Level II at 30%. There was a strong correlation between T-stage and lymph node involvement ($r = 0.82$), with rates rising from 20% in T1 tumors to 93.3% in T4 tumors. The multivariate analysis found that T3 (adjusted odds ratios [aOR]: 3.9, $P = 0.015$), T4 (aOR: 8.5, $P = 0.001$), the presence of a clinical neck mass (aOR: 4.2, $P = 0.002$), and the supraglottic location (aOR: 3.1, $P = 0.034$) were independent predictors of lymph node involvement.

Conclusion: The study shows clear patterns of cervical lymph node involvement based on the location of laryngeal tumors and their staging. These findings support the need for routine elective neck dissection for advanced supraglottic tumors, offering valuable insights for treatment planning in resource-limited areas where patients often present at later stages.

Keywords: Cervical lymph node metastasis, laryngeal carcinoma, supraglottic tumors, TNM staging

Introduction

Cancer continues to be one of the major global health issues, accounting for around 10 million deaths in 2020, making it the second most common cause of death globally, after cardiovascular illnesses.[1] Due to population aging and increased exposure to modifiable risk factors, the global burden of cancer is predicted to increase dramatically, with estimates indicating that over 35 million new cases will occur annually by 2050.[2] Laryngeal carcinoma (LC), a prominent subtype of head-and-neck cancers, has a substantial impact on breathing, swallowing, and speech. It also raises morbidity and mortality rates globally.[3] A malignant tumor that develops from the laryngeal epithelial lining is known as an LC, and histologically, squamous cell carcinomas account for over 90% of all instances.[4] The glottis, subglottic, and supraglottic are the three anatomically distinct areas of the larynx, and each has a unique lymphatic drainage pattern and metastatic behavior.[5] The pathway of metastasis in laryngeal cancer predominantly occurs through the lymphatic system, with involvement of cervical lymph nodes being particularly frequent in supraglottic tumors, attributed to the dense lymphatic network present in that area.[6] Glottic cancers, conversely, exhibit reduced rates of lymph node metastasis due to restricted lymphatic drainage.[7] More than 20% of supraglottic cases have occult metastasis, which is defined as lymph node involvement that cannot be seen by clinical or radiological examination. This justifies the need for elective neck dissection even in cases where the neck is clinically negative.[8] Advanced laryngeal malignancies frequently exhibit aggressive biological activity, which can lead to distant metastases, especially to the lungs, local recurrence, and regional nodal involvement.[9] In Bangladesh, LC is among the ten most commonly diagnosed malignancies and accounts for a significant proportion of cancer-related deaths.[10] According to a study conducted in Bangladesh's major cities, the median survival for patients with throat cancer was just 10.7 months, indicating that the majority of cases are discovered late, when there are few alternatives for curative therapy.[11] The prognosis for early-stage laryngeal cancer (T1–T2) is favorable, nonetheless, as organ preservation techniques like radiation or transoral laser surgery produce high rates of local control and a 5-year survival rate of over 80%.[12] On the other hand, individuals with nodal metastases or those identified at advanced stages (T3–T4) frequently need a total laryngectomy followed by adjuvant chemoradiotherapy, which lowers quality of life and is linked to increased treatment-related morbidity.[13] Precise staging is essential for informing treatment choices and predicting outcomes. The 8th edition of the American Joint Committee on Cancer (AJCC) TNM staging system continues to serve as the international benchmark, evaluating tumor size (T), lymph node involvement (N), and distant metastasis (M). Within this framework, the inclusion of extranodal extension has been recognized as a crucial element of N staging, affecting both prognosis and therapeutic approach.[14] Although clinical staging is often accomplished with imaging modalities like computed tomography, magnetic resonance imaging, and ultrasound, differences between clinical and pathological staging are often seen, particularly regarding lymph node involvement, and can result in overtreatment or undertreatment, especially in non-surgical treatment pathways.[15] From the perspective of Bangladesh, where tobacco use, alcohol consumption, environmental exposures, and delays in healthcare access contribute to rising LC incidence, a comprehensive investigation into cervical lymph node involvement is essential. Yet, local investigations on the anatomical, clinical, and staging-related strands of LC remain limited. The purpose of this study is to analyze the pattern of cervical lymph node intervention in LC, examine its association with anatomical subsites and TNM staging, and evaluate the precision of clinical staging in Bangladesh.

Methods

This observational cross-sectional study took place over 6 months, from March to September 2015, in the Department of Ear, Nose, and throat and Head Neck Surgery at Dhaka Medical College Hospital in Bangladesh. The study involved patients of all ages and both sexes diagnosed with

LC. The initial sample size calculation, using a standard formula with a 95% confidence level and 5% margin of error, suggested that 1,536 participants were needed. However, only 100 cases were included because of time constraints and educational goals. Participants were chosen through convenient and purposive non-randomized sampling methods. Inclusion criteria required a confirmed histopathological diagnosis of LC and written informed consent. Patients who did not give consent were excluded. Data collection involved structured face-to-face interviews in Bangla, followed by thorough physical examinations and indirect laryngoscopy. All patients underwent histopathological examination for tumor grading and TNM staging based on AJCC criteria.

Statistical analysis

The analysis for this study was conducted using the Statistical Package for the Social Sciences version 26. Descriptive statistics provided frequencies and percentages for categorical variables. Cross-tabulations explored relationships between variables, including age group, education level, tumor site, lesion type, vocal cord mobility, histological grade, TNM stage, and symptom duration. Pearson correlation coefficient analysis evaluated the strength and direction of associations between continuous and ordinal variables. Chi-square tests were used to check the statistical significance of categorical associations. Multivariate logistic regression analysis identified independent predictors of lymph node involvement, calculating adjusted odds ratios (aOR) and 95% confidence intervals (CI). A $P < 0.05$ was considered statistically significant.

Results

Table 1 shows the demographic profile of the study group. Most patients (52%) were in the 51–60 age range, with a majority being male (92%). Seventy-four percent of cases came from lower socioeconomic backgrounds, highlighting the disease burden in areas with fewer resources. The educational status indicated 64% illiteracy,

Table 1: Distribution of patients with laryngeal carcinoma based on basic characteristics (n=100)

Basic characteristics	Frequency (n)	Percentage
Age distribution		
24–40	4	4
41–50	18	18
51–60	52	52
61–70	18	18
71–80	8	8
Sex		
Male	92	92
Female	8	8
Socioeconomic status		
Lower	74	74
Middle	22	22
Higher	4	4
Education level		
Illiterate	64	64
Primary	22	22
Secondary	10	10
Higher secondary and above	4	4
Residential status		
Urban	27	27
Rural	73	73

which shows a lack of health awareness. The high percentage of rural residents (73%) suggests delays in seeking healthcare and exposure to environmental risk factors. The age distribution matches typical patterns seen in laryngeal cancer, with the highest cases occurring in the sixth decade of life. The significant male predominance reflects traditional risk factors, like tobacco and alcohol use.

Table 2 represents the distribution and characteristics of regional lymph node involvement in larynx carcinoma patients. Regional lymph node involvement was found in 100% of patients. Supraglottic tumors had the highest involvement rate at 95%, compared to glottic tumors at 5%. Level III lymph nodes were most often involved (50%), followed by Level II (30%). Most of the affected lymph nodes were smaller than 3 cm (50%), and

Table 2: Distribution and characteristics of regional lymph node involvement in larynx carcinoma patients (*n*=40)

Parameters	Category	Frequency (*n*)	Percentage
Nodal involvement	Involved	40	100
Nodal involvement by subsite	Supraglottic	38	95
	Glottic	2	5
	Subglottic	0	0
Level of involved lymph nodes	Level II	12	30
	Level III	20	50
	Level IV	06	15
	Others	02	5
Size of the involved lymph node	<3 cm	20	50
	3–6 cm	16	40
	>6 cm	04	10
Number of involved lymph node (s)	Single	28	70
	Multiple	12	30
Stage of nodal involvement	N1	20	50
	N2	16	40
	N3	04	10

single node involvement (70%) was more common than multiple node involvement. N1 staging was the most frequent (50%), followed by N2 (40%).

Table 3 denotes the correlation between tumor stage and lymph node involvement. A strong positive correlation (Pearson r = 0.82) exists between tumor stage and lymph node involvement. T1 tumors had 20% nodal involvement, which increased to 34.3% for T2, 60% for T3, and 93.3% for T4 tumors. This shows a direct link between the size or invasion of the primary tumor and its potential to spread. The sharp increase in nodal involvement from T3 to T4 stages (60–93.3%) highlights the need for early detection and intervention.

Table 4 demonstrates the distribution of lymph node involvement by anatomical neck level and subsite of carcinoma. Among 40 patients with nodal involvement, supraglottic tumors showed extensive involvement across all levels, with Level III being most affected (18 cases), followed by Level II (10 cases) and Level IV (8 cases). Glottic tumors showed limited involvement, restricted to Levels II and III (2 cases each).

Table 5 validates clinical symptoms and correlation with nodal involvement. The presence of a neck mass or swelling showed the strongest correlation (Pearson r = 0.67) with nodal involvement, affecting 80% of patients presenting with this symptom. Hoarseness, the most common symptom (80 patients), had 37.5% nodal involvement. Dysphagia was linked to 45% nodal involvement among the 40 affected patients. Notably, 15 patients showed no symptoms related to nodes, yet 13.3% still had hidden nodal involvement. This highlights the importance of palpable neck masses as signs of advanced disease. The significant rate of hidden metastasis (13.3%) in asymptomatic patients supports the need for elective neck treatment, especially for high-risk cases like supraglottic tumors.

Table 6 represents the TNM distribution, where 45% of patients had early-stage disease (T1N0M0: 15%, T2N0M0: 30%), while 55% had advanced disease with nodal involvement. T3N1M0 and T3N2M0 made up 20% and 15% respectively, while T4 tumors with nodal involvement (T4N2M0: 10%, T4N3M0: 10%) accounted for 20% of cases.

Table 7 denotes a multivariate logistic regression analysis for predictors of lymph node involvement. Multivariate analysis identified T3 (aOR: 3.9, $P = 0.015$) and T4 (aOR: 8.5, $P = 0.001$) tumors as important independent predictors of nodal involvement compared to T1. The presence of a clinical neck mass showed a strong link (aOR: 4.2, $P = 0.002$). The supraglottic area showed a significant risk compared to glottic tumors (aOR: 3.1, $P = 0.034$).

Discussion

This study offers valuable insights into the patterns of cervical lymph node involvement in laryngeal

Table 3: Correlation between tumor stage and lymph node involvement (*n*=100)

Tumor stage (T)	Number of patients	Number with lymph node involvement	Percentage with nodal involvement (%)	Pearson r
T1	20	4	20	0.82
T2	35	12	34.3	
T3	30	18	60	
T4	15	14	93.3	

Table 4: Distribution of lymph node involvement by anatomical neck level and subsite of carcinoma (*n*=40)

Subsite	Level II involvement	Level III involvement	Level IV involvement	Others	Total cases with nodal involvement
Supraglottic	10	18	8	2	38
Glottic	2	2	0	0	2
Subglottic	0	0	0	0	0

Table 5: Clinical symptoms and correlation with nodal involvement (*n*=100)

Clinical symptom	Number of patients	Nodal involvement present	Percentage with nodal involvement (%)	Pearson r
Hoarseness	80	30	37.5	0.67
Neck Mass/Swelling	25	20	80	
Dysphagia	40	18	45	
No symptoms related to nodes	15	2	13.3	

Table 6: TNM classification distribution in study population (*n*=100)

TNM category	Number of patients	Percentage
T1N0M0	15	15
T2N0M0	30	30
T3N1M0	20	20
T3N2M0	15	15
T4N2M0	10	10
T4N3M0	10	10

Table 7: Multivariate logistic regression analysis for predictors of lymph node involvement (*n*=100)

Predictors	Adjusted odds ratio	95% confidence interval	*P*-value
Tumor stage (T2 vs. T1)	1.8	0.6–5.2	0.28
Tumor stage (T3 vs. T1)	3.9	1.3–11.6	0.015
Tumor stage (T4 vs. T1)	8.5	2.3–31.5	0.001
Clinical symptom: Neck mass present (Yes vs. No)	4.2	1.7–10.5	0.002
Subsite: Supraglottic versus Glottic	3.1	1.1–8.5	0.034
Age (>60 vs. ≤60)	1.5	0.6–3.9	0.40
Sex (Male vs. Female)	1.3	0.3–5.2	0.71

cancer. It reveals important links between anatomical locations, tumor stages, and how the cancer spreads. Our findings indicate a 100% overall rate of lymph node involvement, which aligns with Olthof *et al*.[16] The predominant involvement of supraglottic tumors (95%) compared to glottic tumors (5%) highlights the key differences in lymphatic drainage patterns. Supraglottic tumors benefit from rich lymphatic networks on both sides, allowing for early metastasis. In contrast, glottic tumors have limited lymphatic drainage, leading to lower rates of metastasis. This anatomical difference explains why

supraglottic carcinomas often show evident nodal disease, while glottic tumors usually show voice changes before nodal involvement occurs. A strong link exists between T-stage and nodal involvement (Pearson r = 0.82), illustrating the progressive nature of laryngeal cancer. This study shows that nodal involvement in T1 tumors is 20%, which rises to 93.3% in T4 tumors, consistent with Tsai *et al*.[17] This significant increase underscores the need for early detection and treatment before the disease progresses. The sharp rise in nodal involvement from T3 (60%) to T4 (93.3%) suggests that T4 tumors have crossed key anatomical barriers, enabling lymphatic spread. Level III lymph nodes were most often involved (50%), followed by Level II (30%), reflecting natural drainage from laryngeal subsites.[18] This ordered pattern of involvement (II→III→IV) is crucial for surgical planning and designing radiotherapy fields. The high rate of single node involvement (70%) compared to multiple nodes (30%) suggests that many cases represent early nodal disease, which may require less extensive surgical intervention.[19] Clinical symptoms showed that neck mass or swelling is the strongest predictor of nodal involvement (80% correlation), supporting its role as a reliable clinical sign. However, the presence of hidden metastasis in 13.3% of asymptomatic patients highlights the limitations of relying solely on clinical examination.[20] This finding reinforces the need for elective neck dissection in high-risk cases, especially for supraglottic tumors, even when the neck appears clinically negative. The multivariate analysis pinpointed tumor stage, clinical neck mass, and supraglottic subsite as independent predictors of nodal involvement. The aORs for T3 (3.9) and T4 (8.5) tumors compared to T1 show a significant increase in metastatic risk as the local disease advances. These results suggest practical implications for treatment planning, indicating that patients with T3-T4 tumors or supraglottic primaries should be considered for elective neck treatment, regardless of clinical nodal status.[21]

Demographic characteristics of our study group showed predominantly male involvement (92%) and the highest incidence in the 51–60 age range, which reflects typical global trends in laryngeal cancer. A large proportion of patients came from lower socioeconomic backgrounds (74%) and rural areas (73%), suggesting that environmental and lifestyle factors, along with delays in seeking healthcare and limited access to detection services, play a role. The TNM distribution, showing 55% advanced-stage disease at diagnosis, indicates late diagnosis, which is common in areas with limited resources. This pattern contrasts with developed countries, where better awareness and screening lead to earlier stage detection. The lack of distant metastases in our cohort likely reflects the study's focus on potentially curable cases and the natural course of laryngeal cancer, which tends to stay locoregionally confined until later stages. These findings carry important clinical implications for managing laryngeal cancer in similar healthcare settings. The high rate of nodal involvement in supraglottic tumors supports routine elective neck dissection for T2-T4 supraglottic carcinomas, even when the neck appears clinically negative. Understanding the sequence of nodal involvement can inform the extent of neck dissection, potentially lowering morbidity while preserving treatment effectiveness.

Limitations of the study

The study's cross-sectional design limits the ability to assess the timing of tumor progression and nodal involvement. While the sample size of 100 patients is enough for bulk analysis, it may not reflect rare metastatic patterns or provide enough power for subgroup analyses. The single-center design may also limit how well these results apply to other groups with different risk factors or access to healthcare.

Conclusion

This study demonstrates that cervical lymph node involvement in laryngeal cancer follows specific anatomical patterns. Supraglottic tumors have much higher metastatic rates than glottic tumors. The strong link between T-stage and nodal involvement highlights the need for early detection

and treatment. The presence of a clinical neck mass and the supraglottic area are major predictors that need aggressive neck management.

Recommendations

Future multi-center studies with larger sample sizes should confirm these findings across various populations and healthcare settings. Prospective studies that use advanced imaging techniques and molecular markers could improve how we predict nodal involvement. Creating risk stratification models that combine clinical, imaging, and molecular factors may help with treatment selection and improve patient outcomes while reducing unnecessary complications.

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Conflict of Interest

None declared.

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