International Journal of Multiphysics
Volume 18, No. 3, 2024
ISSN: 1750-9548

The Utility of CT-based Node Reporting and Data System (NODE-RADS) in Assessment of Metastatic Lymph Nodes in nasopharyngeal carcinoma

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Abstract:
Background: The Node Reporting and Data System (Node-RAD) technique allows for more precise assessment of lymph node involvement in nasopharyngeal carcinoma tumors, resulting in better management decisions. Therefore, we used NODE-RADS to evaluate metastatic lymph nodes in nasopharyngeal carcinoma.
Methods: This study comprised 12 cases with nasopharyngeal carcinoma who were referred from the ENT Department between February and August 2023. The NODE-RADS system was evaluated in all situations.
Results: Application of NODE_RADS scoring system in nasopharyngeal cancers had accuracy, sensitivity, specificity, PPV, and NPV of 83.33%, 85.71%, 80%, 85.71%, and 80%, respectively, for evaluating lymph node involvement in nasopharyngeal cancers, implying a clear distinction between benign and malignant cases, with higher NODE-RADS scores strongly associated with metastatic LNs.
Conclusion: A simple NODE_RADS scoring system for CT characteristics of lymph nodes can be used to stratify the risk of cervical lymph node metastasis with high diagnostic accuracy in cases of nasopharyngeal cancers. In everyday practice, this comprehensive and helpful NODE_RADS scoring system, which is based on numerous CT findings, may be useful in evaluating whether patients with nasopharyngeal carcinoma have lymph node metastases.

Keywords: Node Reporting and Data System (NODE-RADS), Nasopharyngeal carcinoma, Lymph Nodes.

Introduction

"Node-RADS" tackles the lack of agreement in radiologic assessment of metastatic lymph nodes while also meeting the increased requirement for systematic reporting on disease involvement. Version 1.0 of the Node Reporting and Data System (Node-RADS) evaluates the amount of suspicion of lymph node involvement by combining approved imaging data. Assessment categories with values ranging from 1 ("extremely low likelihood") to 5 ("very high likelihood") include simple descriptions of imaging data for the two proposed score categories "size" and "configuration." This scoring technique is effective for determining the likelihood of lymph node involvement on CT scans. It is applicable to any anatomical location, including regional and non-regional lymph nodes in relation to the underlying tumor site. Node-RADS will encourage uniformity in reporting and improve communication with referring physicians in primary staging and response assessment circumstances.**[1]**.

Lymph node examination is important in cancer staging because it is a powerful negative prognostic indicator that frequently influences patient treatment and distinguishes surgical candidates from those who are best suited to non-surgical management. The histological type and grade of the tumor typically determines the likelihood of nodal involvement, which increases with tumor size and stage **[2].**

Although nodal size is well recognized, there is still no practical agreement on which of the several studies that have evaluated the morphologic features of the lymph node to use. Size is determined in parallel using volumetric measurements, short-axis diameters, and long-axis diameters. Conversely, lymph node size is not a reliable predictor of subsequent cancer **[3].**

Thus, structured reports can help support research studies while also improving the validity and reliability of imaging assessments in clinical practice **[4].**

Methods

The study's 12 participants included six females and six males, ranging in age from 57 to 81 years. The average age was 67.83± 8.36 years. From February 2023 to August 2023, our patients were referred from the ENT Department for radiological correlation by multidetector CT test with intravenous contrast material. Patients who participated in this study were required to sign a formal consent form after being fully informed of the contents and potential dangers. IRB Approval No. 9172-22-12-2021.

The trial included adult patients without sex preferences who had advanced nasopharyngeal cancer and arrived with a neck lump for evaluation. The study excluded patients below the age of 18yrs and those who refused to give their consent.

Every case had a detailed history taken, a comprehensive clinical examination, laboratory testing, a neck multidetector CT with intravenous contrast medium, and a histopathological investigation.

CT image acquisition:

The multidetector CT examination was carried out using a dual source 128 slice Philips Ingenuity Core 128 channel multidetector CT scanner. To help the patient lower their shoulders as much as possible, we insisted on making them comfortable before the inspection.

The patient was placed in a supine position and permitted to breathe gently. To compare symmetrical anatomy with arms close to the body on the bed, the neck was slightly lengthened, and the head was positioned in the cephalocaudal axis.

A scanogram covering the entire area from the top of the aortic arch to the lower edge of the frontal sinus allowed for a thorough assessment of lymph node status. Starting scans from the cranial to the caudal region lowers artifacts at the thoracic inlet level by enabling the contrast medium concentration in the subclavian vein, at the injection site, to fall to a level comparable to or only slightly higher than other neck vessels.

Axial, reformatted sagittal and coronal images were acquired.

Image Analysis

Following the test, images were analyzed for any abnormality in soft tissue density. Nasopharyngeal carcinomas were examined for areas of increased soft tissue density that would disrupt the typical symmetrical architecture, Examined lymph nodes were assessed regarding (size and morphology).

Reference standard:

Histological findings from surgery (excisional or true cut for 12 LNs) or percutaneous US-guided FNAC samples were used to confirm the final diagnosis of LNs.

Statistical Analysis

The data was imported using the PROC tools and the Statistical Package for Social Science (SPSS) version 22.0 (IBM, Armonk, NY).

Results

Table (1): Distribution of the cases studied according to baseline data (n = 12).

(A) Distribution of cases according to gender and age		
	Number of cases	**Percentage (%)**
Gender		
Male	6	50%
Female	6	50%
Age (years)		
Min. – Max.	57.0 – 81.0	
Mean ± SD.	67.83± 8.36	
Median (IQR)	65.0 (67)	

(B) Distribution of cases according to clinical presentation

Clinical Presentation	**Positive**	**Percentage of Positive Cases (%)**	**Negative**	**Percentage of Negative Cases (%)**
Nasal obstruction	6	50%	6	50%
Nasal bleeding	4	33.3%	8	66.7%
Dyspnea	6	50%	6	50%
Dysphagia	6	50%	6	50%
Voice change	2	16.7%	10	83.3%

Table(1) (A): This table shows that there were 6(50%) male, 6(50%) female, the mean age 67.83 (± 8.36 SD) with range (57-81), **Table (1) (B):** This table shows that the most prevalent clinical presentations among the twelve patients are dyspnea, dysphagia and nasal obstruction, occurring in 50% of cases. These are followed by nasal bleeding at 33.3%. The least frequent clinical presentation is voice change, with frequencies of 16.7%. (Table 1).

Table (2): **A:** Distribution of scored cases studied according to different parameters, **B:** Descriptive analysis of the cases studied according to different parameters

(A) Distribution of cases according to different parameters		
	Number of cases	**Percentage (%)**
Axial AP tumor mass diameter in mm:		
25-30	5	41.7%
30-35	2	16.7%
35-40	2	16.7%
40-45	3	25%
Nodal AP Axial diameter in mm:		
10 - 15	4	33.3%
15 - 20	2	16.7%
20 - 25	2	16.7%
25 - 30	2	16.7%
30 - 35	2	16.7%
Node-RADS Scoring:		
1	2	16.7%
2	2	16.7%
3	3	25%
4	3	25%
5	2	16.7%

(B) Descriptive analysis of cases according to different parameters				
	Number of cases	**Min. – Max.**	**Mean±SD.**	**Median (IQR**
Axial AP tumor mass diameter in mm	12	25–45	31.25±6.44	30 (13.75)

Nodal AP Axial diameter in mm	12	10–35	18.33±7.78	17.5 (15)

Table (2) (A): The table details the frequency and percentage of cases by axial AP tumor mass diameter, nodal AP axial diameter, and Node-RADS scores. Tumor mass diameters are mostly concentrated between 25-30mm. Nodal diameters show a relatively even distribution across the measured ranges. Node-RADS scores vary from 1 to 5, with intermediate scores (3 and 4) being the most common. **Table (2)** (**B):** This table shows that the mean axial AP tumor diameter is 31.25 (±6.44 SD) with range (25-45), the mean nodal AP axial diameter is 18.33 (± 7.78 SD) with range (10-35).

Table (3): Show distribution of presented cases according to enlarged nodal border and shape.

(A) Distribution according to border of enlarged LN		
Border of Enlarged Lymph nodes	**Number of cases**	**Percentage (%)**
Smooth	6	50
Irregular or Ill-defined	6	50
(B) Distribution according to shape of enlarged LN		
Enlarged node shape	**Number of cases**	**Percentage of total cases (%)**
Any shape with preserved fatty hilum	0	0%
Kidney-bean-like or oval without fatty hilum	5	41.7%
Spherical without fatty hilum	7	58.3%

Table (3)(A): The table shows that Irregular or ill-defined borders were observed (50%) and smooth borders (50%) in our sample, **Table (3)(B):** The table presents the distribution of enlarged lymph node shapes in relation to the preservation of the fatty hilum. All cases lacked a preserved fatty hilum. The majority of nodes (58.3%) were spherical in shape, while 41.7% appeared kidney-bean-like or oval. No cases were observed with a preserved fatty hilum, indicating its complete absence across the sample. (Table 3).

Table (4): Show different NODE-RADS scoring in our twelve cases.

Malignant mass	**NODE_RADS Score**	**Number of cases**
Nasopharyngeal carcinoma (12 cases)	Score 5	2
	Score 4	3
	Score 3	3
	Score 2	2
	Score 1	2

This table illustrated the distribution of NODE-RADS scores among 12 patients diagnosed with nasopharyngeal carcinoma. All five scoring categories (1 to 5) are represented. Intermediate scores (3 and 4) were the most frequent, with 3 cases each. Lower scores (1 and 2) and the highest score (5) were less common, each containing 2 cases. (Table 4).

Table (5): The utility of NODE_RADS scoring system for prognosis of affected lymph nodes in patients with Nasopharyngeal carcinoma.

Parameters	Evaluated items
Cut-off	≥10
Number of true-positive findings	6
Number of false-negative findings	1
Number of false-positive findings	1
Number of true-negative findings	4
Accuracy (%)	83.33
Sensitivity (%)	85.71
Specificity (%)	80
Positive Predictive Value (%)	85.71
Negative Predictive Value (%)	80
Positive Likelihood Ratio	4.29
Negative Likelihood Ratio	0.18

This table demonstrates that the NODE-RADS scoring system achieved a high overall accuracy of 83.33%, indicating reliable performance in differentiating between benign and malignant lymph nodes. The sensitivity was 85.71%, showing that the system successfully identified the most malignant cases using a cut-off of ≥10. The specificity reached 80.00%, indicating a strong ability to correctly exclude benign cases. The positive predictive value (PPV) of 85.71% suggests that a positive NODE-RADS score is highly indicative of malignancy, while the negative predictive value (NPV) of 80.00% demonstrates good reliability in ruling out disease when the score is low. Furthermore, the positive likelihood ratio (PLR) of 4.29 supports a meaningful diagnostic benefit of a positive score, and the negative likelihood ratio (NLR) of 0.18 further strengthens the clinical utility of a negative result in excluding malignancy (Table 5).

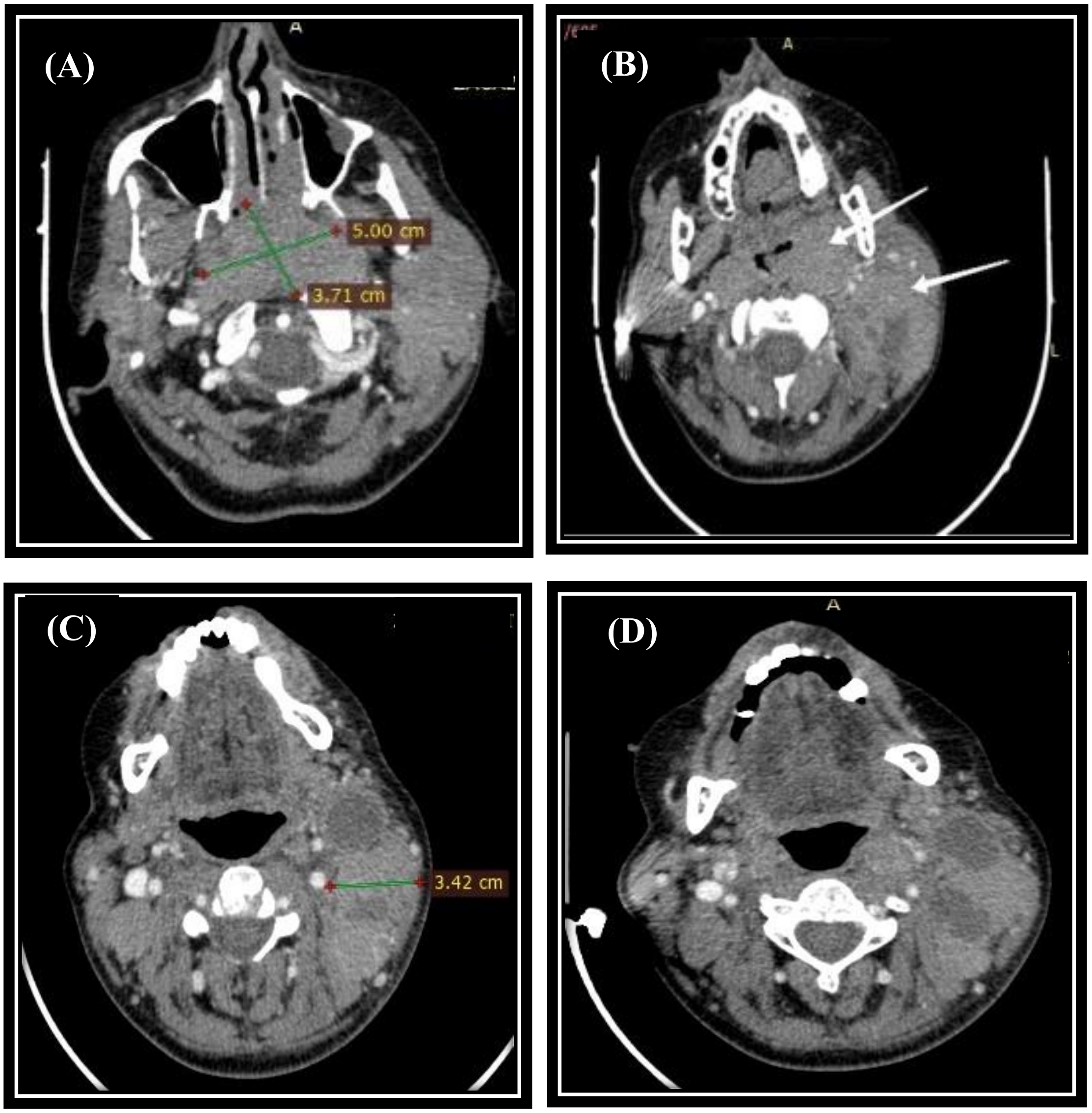


Figure (1): 70 yrs old female presented by lump in her neck at LT side, nasal congestion, blood in saliva, partial hearing loss. Multidetector CT axial views with IV contrast (A) MDCT Axial cuts show nasopharyngeal mass measurement (5x3.7cm). (B) it's encroaching upon oropharynx with large amalgamated LNs showing internal cystic degeneration. (C) Multiple amalgamated lymph nodes measures (34mm at short axis). (D) another clear view to internal cystic degenerated LNs.

Figure (1) showed:

- Multidetector CT axial views with intravenous contrast revealing a well-defined homogenously enhanced mass lesion seen at nasopharynx measures about 5x3.7 cm, encroaching up on nasopharyngeal airway, the mass extends to oropharynx, Multiple amalgamated bilateral cervical LNs most with internal cystic degeneration, largest measures 34 mm at short axis.

- Scoring of amalgamated LNs using NODE-RAD system gives it score 5- very high probability of metastasis.

Explanation to score: Bulky size (>30mm) So NODE-RADS=5

- Pathological reports give knowledge of Nasopharyngeal carcinoma (Keratinized type, Grade II).

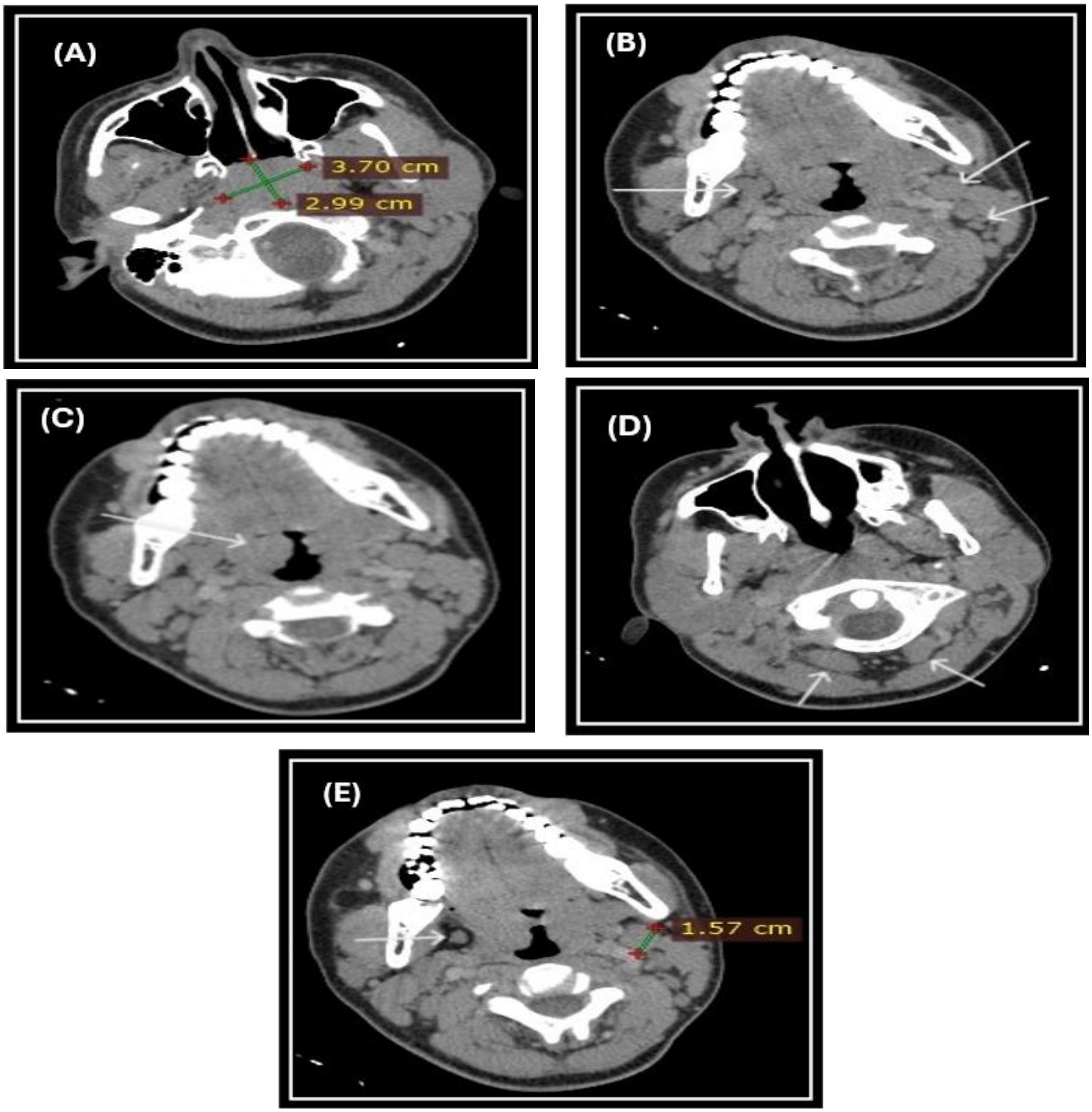


Figure (2): 69 years old male presented by area of bilateral neck swelling peri-auricular more on Rt side, difficult swallowing, persistent fatigue**.** Multidetector CT Axial cuts with IV contrast (A): show nasopharyngeal mass measurement (3.7x2.9cm) that obliterates nasal airway with enlarged LT parotid group (level VIII) plus retro auricular, subauricular groups. (B): enlarged submandibular, anterior jugular, posterior jugular groups, (C) oropharyngeal extension of nasopharyngeal mass, (D): also enlarged bilateral occipital LNs (level Xb) noted, (E): measurement of largest LT anterior upper jugular LN (level II) (15mm in short axis) with small right submandibular one.

Figure (2) showed:

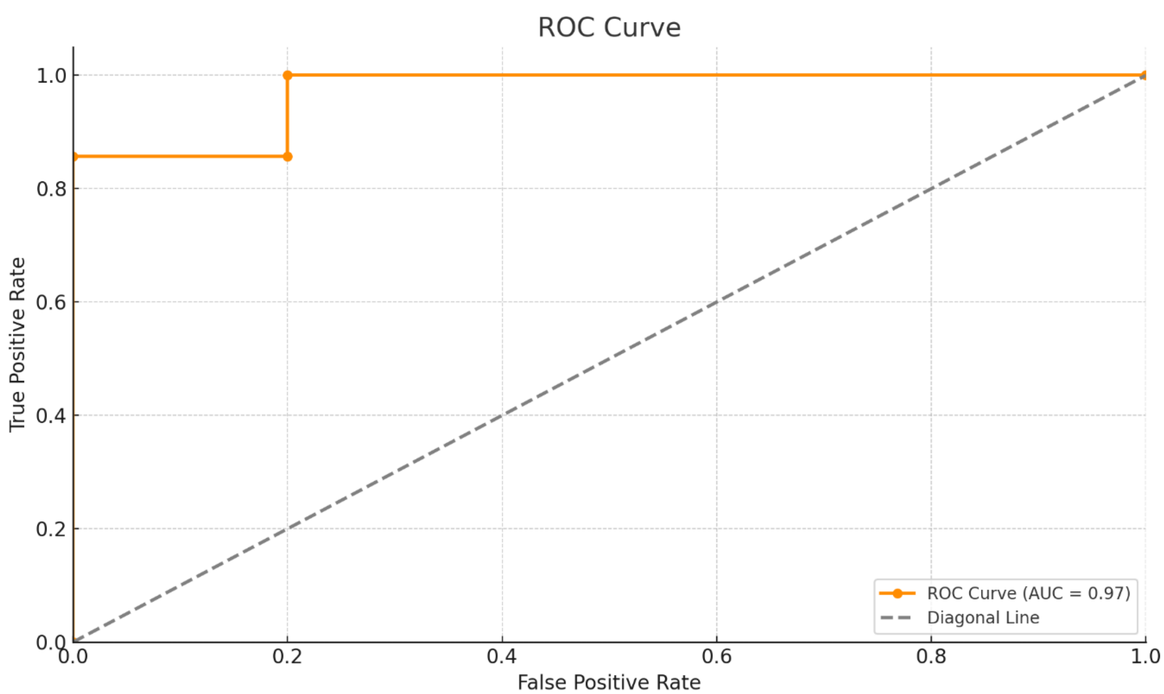
- Multidetector CT axial views with intravenous contrast revealing a fairly defined mass arising from lateral walls of nasopharynx reaching base of the tongue, extending to RT side of oropharynx measures about (3.7x2.9cm) associated by multiple bilateral enlarged cervical LNs largest at level IIa, LT sided measures 16mm

- Scoring the largest cervical LN using NODE-RAD system gives it a score of 4(high probability of metastasis).

- Explanation to score: (A) size: enlarged, (B) configuration:1) texture:0 homogenous, 2) Border: 1, irregular. 3) shape:1, spherical without fatty hilum, So NODE-RADS=4

- Pathological reports give results of Nasopharyngeal carcinoma with metastatic lymph nodes.

Figure (3): ROC curve for total score to diagnose cervical LNs metastases.



The ROC analysis of the NODE-RADS scoring system demonstrated a significantly improved diagnostic performance, with an AUC of 0.97, indicating excellent discriminative ability. At the selected cut-off value of ≥ 10mm, the model achieved a sensitivity of 85.71%, correctly identifying most malignant cases, and a specificity of 80.00%, effectively minimizing the misclassification of benign nodes as malignant.

The high AUC confirms the scoring system's strong ability to distinguish between malignant and benign lymph nodes. These findings support the clinical utility of the NODE-RADS system as a reliable, non-invasive diagnostic tool in evaluating cervical lymph node involvement in head and neck malignancies. Nevertheless, histopathological confirmation remains essential, particularly in ambiguous or intermediate cases.

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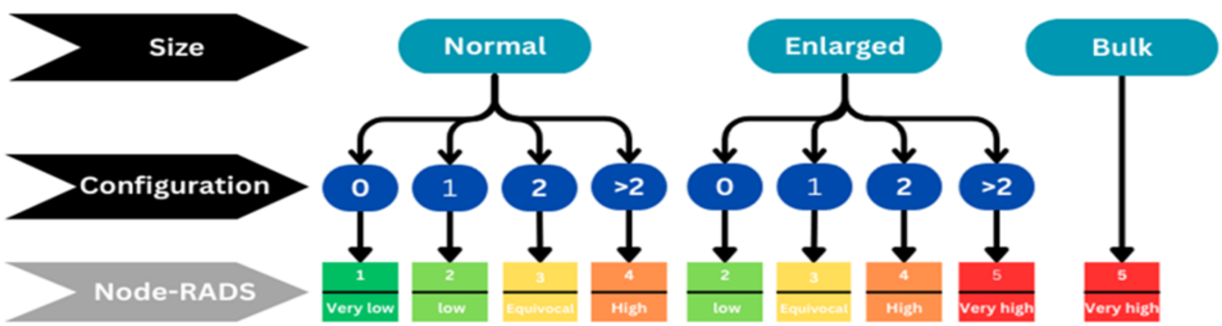
Discussion:

Cervical nodal metastases have a substantial impact on the prognosis of patients with nasopharyngeal carcinoma **[5].** The exact identification of metastatic nodes is critical for the treatment of nasopharyngeal carcinoma. Early identification and treatment of nasopharyngeal carcinoma can improve the prognosis and quality of life significantly **[6].**

Radiologists may find it difficult to assess lymph node metastases in nasopharyngeal carcinoma using imaging since there are many cervical levels to consider and different recommended criteria for metastatic lymph nodes. Furthermore, to determine the risk of metastasis in day-to-day practice, a number of lymph node imaging parameters (such as diameters, shapes, and necrosis), combinations of those findings, and original tumor qualities (such as kind or location) should be considered **[7].**

To maximize the benefits of preoperative CT, a rigorous and methodical approach based on a combination of previously stated criteria is required **[7].** Our study included 12 patients with a maximum axial nodal diameter cutoff of 10 mm. The sensitivity and specificity were 85.71% and 80%, respectively.

According to **Elsholtz et al. [1],** assessing a lymph node using the Node-RADS method provides an assessment category score ranging from 1 to 5, indicating the degree of suspicion for malignancy involvement: "1—very low," "2—low," "3—equivocal," "4—high," and "5—very high." A three-level flowchart is employed to assist the interpreting radiologist in this procedure; levels 1 and 2 address the two key imaging criteria of "size" and "configuration." The resulting Node-RADS assessment score is assigned at Level 3. (figure 4)



Size (Choose One Category)		
Normal Short axis	**Enlarged** Short axis	**Bulk** Any axis
General: < 10 mm Inguinal: < 15 mm Facial parotid, retro auricular, occipital, retropharyngeal, anterior jugular: <5mm Cardio-phrenic, retro crural, obturator, mesorectal: <5mm	Larger than normal, but no bulk ≥ 2 mm increase from prior imaging (if available)	≥ 30 mm

Configuration Scoring (Choose One Feature per Category, Sum Scores)					
Texture		**Border**		**Shape**	
Homogeneous	0	Smooth	0	Any shape with preserved fatty hilum	0
Heterogeneous	1	Irregular or ill-defined	1	Kidney-bean-like/oval, no fatty hilum	0
Focal necrosis	2			Spherical, no fatty hilum	1
Gross necrosis or any new necrosis	3				
Entity-specific findings*	3				

*Entity-specific findings include a) Cystic appearance (HPV+ squamous cell carcinoma, thyroid cancer, non-seminomatous germ cell tumor). b) Calcifications (thyroid cancer). c) Mucinous texture (mucinous adenocarcinoma).

Figure (4): Node-RADS flowchart with a brief description of the criteria for lymph node assessment.

Zhong and his colleagues' investigation, published on April 15, 2024, found identical results. As the top category rose, they discovered that Node-RADS showed good diagnostic performance with a higher risk of malignancy. This is consistent with our findings, which showed that the highest occurrence of nodal malignancy was associated with the highest NODE-RAD score **[8].**

However, there is inadequate evidence to support Node-RADS' inter-observer reliability, making it difficult to use in clinical settings for lymph node evaluation **[8].**

The AUC for Node-RADS is 0.97 in ascending order of score>1, >2, >3, >4, and 5., in this study, we use a cut-off value of 10mm.

Cross-sectional study of individuals who had pretreatment contrast-enhanced neck computed tomography scans between February and August 2023 and were recently diagnosed with nasopharyngeal carcinoma. Our study included twelve cases of nasopharyngeal cancer, with a mean age of 67.83± 8.36 SD years, a range of (57-81) years, and a median age of 65 years. There were six males (50%) and six females (50%).

These findings are comparable with those of **Dhull et al. [9],** who discovered that half of 9,950 patients with head and neck cancer were between the ages of 50 and 70. Furthermore, a study conducted in Iraq found that the majority of patients were aged 60 to 70 **[10].**

Male patients account for 50% of the cases in our study. This is in contrast with the findings of **Stovanov et al. [11],** who discovered that 76.41% of head and neck cancer cases were male and 23.59% were females. Our study's smaller sample size may explain why their share is higher.

The chief clinical signs in our study were a neck mass, nasal blockage, nasal bleeding, dysphagia and hoarse voice. All cases had nasopharyngeal tumor, dysphagia, dyspnea and nasal obstruction were the most prevalent symptoms (occurring in 50% of cases).

. Furthermore, **Fasunla et al. [12]** investigated 97 patients and documented the symptoms they observed, which included hoarseness, coughing, breathing difficulty, referred otalgia, dysphasia, a lump in the throat (11%), throat pain, and neck swelling. The most common symptoms among the cases were dysphagia and dyspnea, which were also found in our investigation.

Furthermore, our findings give sensitivity of 85.71%, and specificity of 80%, PPV 85.71%, NPV 80%, demonstrates good reliability in ruling out disease when the score is low.

Our findings complement **Castelijns and colleagues' [13] 2002** work, which underlined the importance of radiographic criteria in detecting nodal metastases. Significant indications of metastatic involvement were discovered during their examination, including increased size, a rounder shape, and the emergence of non-contrast-enhancing patches or inconsistent contrast enhancement due to tumor necrosis. They also noticed that using the minimal axial diameter instead of the maximal diameter improved the accuracy of the results.

In a 1992 investigation, **Yousem and colleagues [14]** discovered that CT is more sensitive and reliable than MRI in detecting nodal necrosis.

PET/CT is acknowledged as useful for staging the nodal status of malignant tumors of the head and neck. A recent meta-analysis found that PET/CT had an 84% sensitivity, 96% specificity, and 0.97 AUC, with a 21% increase in sensitivity in each neck level compared to traditional imaging **[15].**

CT is a standardized objective imaging technology that requires less operator intervention than u/s, and various studies have examined its diagnostic efficacy for cervical lymph node metastases. Furthermore, CT provides systematic, full axial anatomic information spanning the base of the skull to the mediastinum. CT can also evaluate lymph nodes in the mediastinum, retrosternal, and retropharyngeal regions, as well as in cases of limited patient cooperation or poor patient condition **[16].**

As a result, our prediction model, which provides risk stratification for lymph node evaluation, has the potential to provide objective evidence for diagnosis and reduce interobserver variability in the detection of node metastases in nasopharyngeal carcinoma.

Conclusion:

A simple NODE_DADS scoring system for CT features of lymph nodes with IV contrast may be able to stratify the risk of cervical lymph node metastasis with high diagnostic accuracy in cases of nasopharyngeal carcinoma. In everyday practice, this comprehensive and helpful NODE_RADS scoring system, which is based on numerous CT findings, may be useful in evaluating whether patients with nasopharyngeal cancer have lymph node metastases.

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