Introducing the Node Reporting and Data System 1.0 (Node-RADS): a concept for standardized assessment of lymph nodes in cancer

Fabian H. J. Elsholtz 1 · Patrick Asbach 1 · Matthias Haas 1 · Minerva Becker 2 · Regina G. H. Beets-Tan 3 · Harriet C. Thoeny 4 · Anwar R. Padhani 5 · Bernd Hamm 1

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Abstract

“Node-RADS” addresses the lack of consensus in the radiologic assessment of lymph node involvement by cancer and meets the increasing demand for structured reporting on the likelihood of disease involvement. Node Reporting and Data System 1.0 (Node-RADS) systematically classifies the degree of suspicion of lymph node involvement based on the synthesis of established imaging findings. Straightforward definitions of imaging findings for two proposed scoring categories “size” and “configuration” are combined into assessment categories between 1 (“very low likelihood”) and 5 (“very high likelihood”). This scoring system is suitable for assessing likely involvement of lymph nodes on CT and MRI scans. It can be applied at any anatomical site, and to regional and non-regional lymph nodes in relation to a primary tumor location. Node-RADS will improve communication with referring physicians and promote the consistency of reporting for primary staging and in response assessment settings.

Key Points

• Node-RADS standardizes reporting of possible cancer involvement of regional and distant lymph nodes on CT and MRI.
• Node-RADS proposes the scoring categories “size” and “configuration” for assigning the 5-point Node-RADS score from 1 (“very low likelihood”) to 5 (“very high likelihood”).
• Node-RADS aims to increase consensus among radiologists for primary staging and in response assessment settings.

Keywords Consensus · Lymph nodes · Magnetic resonance imaging · Neoplasms · Tomography, X-ray computed

Anwar R. Padhani and Bernd Hamm contributed equally to this work and share the last authorship.

Abbreviations
HN Head and neck
MRI Magnetic resonance imaging
NI Neck imaging
RADS Reporting and data system
TNM Tumor, nodes, metastasis

Introduction

Background

Evaluation of lymph nodes for the likelihood of disease involvement is important in the context of cancer staging because nodal involvement is a powerful adverse prognostic indicator that often determines patient management, frequently distinguishing surgical candidates from those best suited for non-surgical management [1, 2]. In most cases, the incidence
of nodal involvement increases with tumor bulk and stage and is dependent on tumor histological type and grade.

Even though numerous studies have evaluated morphologic criteria in computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound (US), practically there is still no consensus on which criteria should be used, although nodal size is generally accepted [3]. Paralleling approaches to assess size include short- and long-axis diameters, as well as volumetric measurements. However, lymph node size is a poor indicator for predicting the presence of secondary malignancy. In a study focusing on mesorectal lymph nodes in rectal cancer patients, Gina Brown and colleagues showed a broad size overlap between histologically benign (2–10 mm) and malignant (3–15 mm) lymph nodes [3]. Furthermore, using nodal size as a criterion for metastatic involvement can be confusing in the head and neck (HN) region as benign nodes have different sizes depending on patient age and on anatomic location; e.g., submandibular nodes are typically larger than lymph nodes in other neck groups (sometimes called stations/levels). The choice of the size cutoff will influence sensitivity and specificity for the detection of nodal metastases. In a HN study, Curtin and colleagues showed that a size cutoff of 10 mm in the largest axial nodal diameter results in a sensitivity and specificity of 88% and 39%, respectively, whereas a size cutoff of 15 mm yielded corresponding values of 56% and 84%, respectively [4]. Also, there is no consensus on whether lymph nodes should be measured in the axial or craniocaudal dimensions.

Criteria for lymph node configuration also exist with numerous descriptors, which can sometimes be helpful [5–8]. There have been some promising approaches by combining size and configuration criteria to facilitate and standardize the diagnostic workup for lymph nodes at specific anatomic locations, such as in the mesorectum in a European Society of Gastrointestinal and Abdominal Radiology (ESGAR) consensus statement [9]. However, focusing on specific disease entities and body sites limits the practical application of the approach in clinical practice.

In addition to being highly dependent on the interpretative skills of radiologists, unstructured reports that use a variety of terms to describe the likelihood of disease involvement also cause difficulties for clinical referrers making treatment decisions. Recently, there have been attempts at standardizing the reporting of oncologic scans with the increasing adoption of the Reporting and Data Systems (RADS) for many scenarios for the detection and characterization of lesions within specific organs. For example, BI-RADS is well established for reporting on the detection of breast cancer using x-ray mammography [10]. Recently, other systems incorporating the RADS acronym have emerged including LI-RADS for the MRI evaluation of hepatocellular carcinoma in liver cirrhosis, NI-RADS for surveillance of head and neck cancer, and PI-RADS for the MRI detection of prostate cancer, finding acceptance among radiologists and referring clinicians alike [10–13]. Structured reports can improve the reliability and validity of imaging assessments in the clinical routine but can also aid research studies and audits.

Generally, -RADS systems incorporate a Likert-type scale for the likelihood of the target disease being present. The use of scoring systems to assess the likelihood of malignant disease involvement has emerged, but is limited to specific body sites, cancer entities, time of evaluation, or imaging modalities [14–17]. There is no generally applicable imaging system for the whole body that indicates the scaled likelihood of malignant nodal disease involvement.

**Purpose**

Node-RADS is a concept that addresses the aforementioned limitations, aiming to enhance the reporting of regional and distant lymph nodes in cancer patients by (i) clearly defining imaging criteria to increase consensus among radiologists, (ii) facilitating standardized lymph node reporting, and (iii) having broad applicability to cancer types across multiple anatomic sites, being evaluated by CT and/or MRI. To serve these purposes, the Node-RADS scheme is graphically depicted, is logically arranged and intuitive, enabling its adoption into the clinically routine without the need for additional time expenditure.

**Rationale and discussion of the system**

**Overview and general considerations**

The evaluation of a lymph node using the Node-RADS scheme results in an assessment category scored between 1 and 5, which reflects the level of suspicion for involvement by malignancy: “1—very low”; “2—low”; “3—equivocal”; “4—high”; “5—very high.” For this purpose, the interpreting radiologist is guided through a three-level flowchart (Fig. 1). Levels 1 and 2 address the two principle imaging criteria of “size” and “configuration.” Level 3 provides the resulting Node-RADS assessment score. Categories, definitions, and features of the respective criteria are also given in Fig. 1.

**Criterion “size”**

There is an ongoing debate about the setting of limits for physiologic and pathologic size of lymph nodes. Ultimately, any chosen size cutoffs depend on the desired sensitivity and specificity concerning the stage of the primary tumor and/or clinical status of patients [18, 19]. Many radiologists do not consider nodal size to be an absolute criterion for the assessment of likely malignant involvement. However, since the size of lymph nodes is a criterion that is widely used, and is
incorporated into the RECIST (Response Evaluation Criteria in Solid Tumors) criteria for response assessment studies [20]. Node-RADS divides nodal sizes into three categories: “normal,” “enlarged,” and “bulk.”

In general, a lymph node is defined to have a “normal” size, when its short-axis diameter is < 10 mm. Node-RADS defines exceptions for normal size for inguinal nodes which could measure < 15 mm in short-axis diameter; on the other hand, Node-RADS sets a lower cutoff for specific subregions, where the normal short-axis diameter should be < 5 mm: facial, parotid, retroauricular, occipital, retropharyngeal, anterior jugular, retrocral, cardio-phrenic, mesenteric, obturator, and mesorectal lymph nodes [20]. A “bulk” is defined as a lymph node with the longest diameter of ≥ 30 mm measured in any dimension. Since there are no generally accepted measurements for the term “bulk,” especially outside of lymphomas, we were guided by the TNM classification for head and neck cancer, where a lymph node diameter of 30 mm is the threshold for N2 (with the exception of HPV-positive oropharyngeal, nasopharyngeal, and thyroid cancer) [1]. Lymph nodes of “enlarged” size do not meet either the definitions of the categories “normal” or “bulk” or are between 10 and 15 mm (short axis) for RECIST purposes, or show interval increases of ≥ 2 mm in short-axis diameter, if prior imaging datasets are available for comparison. The ≥ 2-mm threshold is based on a consideration regarding the spatial resolution of CT scans (512 matrix over a 40–50-cm field-of-view results in a pixel size of 0.78 to 0.98 mm). The requirement of two pixels for a reliable measurement translates into axial dimensions of ≥ 2 mm.

Node-RADS seeks not to overinterpret the size of lymph nodes, which in a specific case means that an “enlarged” lymph node by size criteria without accompanying abnormal morphologic features discussed under the “configuration” criteria (below) will receive a Node-RADS score of 2 (“low suspicion”).

**Criterion “configuration”**

After using the “size” criterion in the first-level evaluation, the second level considers other anatomic features under the criterion of “configuration” which have a critical importance for the final Node-RADS assessment score. The “configuration score” is made up of the summed numerical value from the three sub-categories of “texture,” “border,” and “shape.”

- The category “texture” refers to the internal structure of a lymph node, which is defined as “homogeneous” (0
points), “heterogeneous” (1 point), “focal necrosis” (2 points), and “gross necrosis or any new necrosis” (3 points). Also, 3 points can be assigned if other features summarized under “entity-specific findings” are present: (i) cystic appearance (human papillomavirus positive squamous cell carcinoma of the neck, thyroid cancer, and non-seminomatous germ cell tumor), (ii) calcifications (thyroid cancer), and (iii) mucinous texture (mucinous adenocarcinoma) [12, 21, 22] (Figs. 2 and 3). “Texture” seems to be the most reliably assignable category, which is why the highest numerical values can be achieved here compared with the other categories.

- The category “border” evaluates possible extranodal disease extension. This is very specific in the histopathological sense, but often difficult to diagnose with imaging methods [23]. Therefore, either 0 points (“smooth”) or 1 point (“irregular or ill-defined”) contribute to the configuration score in this category (Fig. 4).

- The third category “shape” covers two features, the geometric shape and the delineation of the fatty hilum. Both features are usually well assessed on high-spatial resolution CT or MRI but are unspecific so that the maximum of 1 point can be assigned: 0 points (“any shape with preserved fatty hilum”) or (“kidney-bean-like or oval without fatty hilum”) 1 point (“spherical without fatty hilum”) (Fig. 5).

One feature is chosen from each sub-category, which translates into a minimum achievable “configuration score” of 0 points, and a maximum possible score of 5 points.

![Figure 2](image1.png)

**Fig. 2** a–h Representative images for criterion “configuration,” feature “texture,” part 1 (homogeneous, heterogeneous, focal necrosis, gross necrosis). a Mesenteric, axial, contrast-enhanced (venous phase); b neck level IIa on the left side, axial plane, contrast-enhanced (split-bolus); c neck level V on the left side, axial, contrast-enhanced (split-bolus); d middle mediastinum, axial, contrast-enhanced (venous phase); e parotid space on the right side, axial, T1 weighted, contrast-enhanced fat-suppressed; f parotid space on the left side, axial, T1 weighted, contrast-enhanced fat-suppressed; g parotid space on the left side, axial, T1 weighted, contrast-enhanced fat-suppressed; h parotid space on the right side, axial, T1 weighted, contrast-enhanced fat-suppressed

![Figure 3](image2.png)

**Fig. 3** a–d Representative images for criterion “configuration,” feature “texture,” part 2 (entity-specific findings). a Neck level IIa on the left side, axial plane, contrast-enhanced (split-bolus); b neck level III on the right side, T2 weighted; c neck level IV on the left side, contrast-enhanced (venous phase); d mesorectal adjacent to a T3 mucinous type rectal adenocarcinoma (indicated by a white star), T2 weighted
As indicated in the Node-RADS flowchart (Fig. 1), each “configuration score” consecutively translates into the respective final Node-RADS score.

**Technical considerations**

Node-RADS is applicable for the interpretation of lymph nodes on CT and MRI. Specific technical imaging...
acquisition parameters are not a prerequisite facilitating broad applicability of Node-RADS. The use of contrast material is not mandatory for MRI given the intrinsic high soft tissue contrast. The use of contrast material is mandatory for CT scans, to assess the “configuration” categories, in an appropriate parenchymal phase after intravenous injection.

For baseline staging, anatomic coverage should include all regional lymph nodes of the primary tumor, and, depending on the likelihood for distant metastatic disease, respective body parts (e.g., the chest and upper abdomen (adrenals) for staging HN tumors). For response assessment, anatomic coverage should include all lymph node sites that showed abnormal lymph nodes on baseline imaging.

Structured reporting

To provide the best possible assessment of the nodal status of patients, radiologists are required to (a) know the purpose of the imaging study, i.e., staging at initial diagnosis, suspected recurrence or response assessment; (b) have detailed knowledge of tumor histology and stage of the primary tumor to determine the probability of nodal involvement; (c) have knowledge of the pattern of spread and the prevalence of microscopic disease in normal size nodes (currently possible to some extent only with MR lymphography and PET-CT).

Node reporting rules

• To acknowledge the limitation of imaging to detect microscopic disease in normal size nodes (currently possible to some extent only with MR lymphography and PET-CT).

Staging objectives

• To identify the presence and extent of regional nodal metastases to assign an N-staging category.
• To identify whether the extent of nodal disease will significantly alter the surgical approaches. For example, by increasing the extent of surgical exploration, or the requirement for the placement of vascular grafts.
• To determine whether the presence of metastatic nodal involvement designates M-stage disease.
• To identify the presence and extent of regional nodal enlargement with a view to planning biopsy.
• To distinguish between nodal enlargement due to malignancy and that due to benign hyperplasia.

TNM staging

The TNM system places regional nodal involvement in the N category, but nodal involvement at other than regional sites is classified as distant metastases (i.e., belongs in the M category). It is therefore important for radiologists to know where regional and distant metastatic sites reside for each primary tumor. These details can be found in staging manuals, preferably in the AJCC Cancer Staging Manual [1]. Sometimes, the same organ may have different regional nodal groups; thus, the retroperitoneum is a distant metastatic site for cervical cancer but defined as “regional” for endometrial cancer.
It is important to note that the TNM system emphasizes different aspects for nodal involvement depending on the primary tumor; thus, for the bladder and head and neck cancers, nodal size is part of the N category. For many adenocarcinomas, the presence or absence of microscopic metastatic disease, regardless of primary tumor burden, is emphasized, whereas nodal involvement sometimes does not alter staging category at all (e.g., for well-differentiated follicular/papillary thyroid cancers in patients less than 45 years of age).

**RECIST reporting**

The RECIST system is based on the measurement of target lesions, summing up lesion sizes to assess tumor response to therapy [20]. According to RECIST v1.1., lymph nodes should be measured along the short axis in the axial plane. To be considered pathologically enlarged and measurable, the short-axis diameter should be $\geq 15$ mm. If the short-axis diameter is between 10 and 15 mm, they are considered pathologic, but cannot be used as target sites (non-measurable disease) [24].

In order to account for temporary nodal enlargement without clinical disease progression during immunotherapy, the RECIST system has been modified, so creating the iRECIST (immune-related RECIST) system [25].

The following general rules apply to Node-RADS regarding RECIST:

- Since Node-RADS incorporates the configuration criterion, nodes with a short-axis diameter $< 15$ mm or $< 10$ mm can be assigned a Node-RADS score of 3, 4, or 5 while being considered malignant non-measurable lesions or normal nodes, respectively, according to RECIST 1.1. These must not be regarded as contradictory, rather they reflect the different purposes of the two systems (detection versus response assessments).

- Since RECIST 1.1 is purely size-based, nodes with a short-axis diameter $< 15$ mm can be assigned a Node-RADS score of 2 while being considered pathologic according to RECIST 1.1. Again, this must not be regarded as contradictory, rather they reflect the different purposes of the two systems (see above).

- In the scenario when RECIST 1.1 and Node-RADS differ, this should trigger a careful evaluation of the respective node on follow-up imaging.

- Immunotherapy can induce reactive nodal enlargement and configuration changes that probably alter the Node-RADS score; therefore, iRECIST should be used in the context of likely pseudoprogression, and Node-RADS is not applicable here.

**Compliance with other RADS**

Node-RADS can be used and reported in addition to already existing RADS (e.g., LI-RADS or PI-RADS). An exception is NI-RADS in the surveillance of head and neck cancer, where a score is already assigned for the cervical lymph nodes (“neck”). The criteria and algorithm of Node-RADS and NI-RADS are not concordant.

**Future directions**

Undoubtedly, independent prospective studies on reliability (i.e., inter- and intra-reader agreement) and validity are mandatory to make any adjustments to the Node-RADS system proposed here. Although the combination of CT or MRI with functional sequences (e.g., perfusion imaging) or PET is widely used, these are intentionally not included in Node-RADS at this time to facilitate the straightforward use of the system. Ultrasound is frequently used for evaluation of superficial lymph nodes applying criteria that differ distinctly from CT and MRI and therefore not included in Node-RADS. However, as in existing RADS, changes could expand the scope of the application upon the availability of further evidence [12]. Node-RADS is likely in need to be periodically modified in response to independent prospective studies that evaluate its efficacy, which may include the inclusion of additional imaging features, e.g., clustering of lymph nodes, or adjustments on the size cutoff for bulky disease. Finally, minimum technical imaging parameters might be a subject for inclusion in the standard in future iterations of Node-RADS.

**Conclusion**

The Node Reporting and Data System 1.0 (Node-RADS) standardizes reporting of possible cancer involvement of regional and distant lymph nodes on CT and MR imaging. Node-RADS is applicable at any anatomical site, proposing the use in the scoring of the categories of “size” and “configuration” for assigning the 5-point Node-RADS assessment category score. An increase in the consensus of radiologic assessment of lymph nodes will facilitate uniformity of primary tumor staging, and evaluation of response to treatment.

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Methodology

• Guideline

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References

1. Brierley JD, Gospodarowicz MK, Wittekind C (2017) TNM classification of malignant tumours, 8th edn. Wiley-Blackwell, Chichester

2. Burusapat C, Jarungroonguangchai W, Charoenpitakchai M (2015) Prognostic factors of cervical node status in head and neck squamous cell carcinoma. World J Surg Oncol 13:51

3. Brown G, Richards CJ, Bourne MW et al (2003) Morphologic predictors of lymph node status in rectal cancer with use of high-spatial-resolution MR imaging with histopathologic comparison. Radiology 227:371–377

4. Curtin HD, Ishwaran H, Mancuso AA, Dalley RW, Caudry DJ, McNeil BJ (1998) Comparison of CT and MR imaging in staging of neck metastases. Radiology 207:123–130

5. Mundada P, Varroquaux AD, Lenoir V et al (2018) Utility of MRI with morphologic and diffusion weighted imaging in the detection of post-treatment nodal disease in head and neck squamous cell carcinoma. Eur J Radiol 101:162–169

6. Thoeny HC, Barbieri S, Froehlich JM, Turkbey B, Choyke PL (2017) Functional and targeted lymph node imaging in prostate cancer: current status and future challenges. Radiology 285:728–743

7. Beets-Tan RG (2013) Pretreatment MRI of lymph nodes in rectal cancer: an opinion-based review. Colorectal Dis 15:781–784

8. Loch FN, Ashbach P, Haas M et al (2020) Accuracy of various criteria for lymph node staging in ductal adenocarcinoma of the pancreatic head by computed tomography and magnetic resonance imaging. World J Surg Oncol 18:213

9. Beets-Tan RGH, Lambregts DMJ, Maas M et al (2018) Magnetic resonance imaging for clinical management of rectal cancer: updated recommendations from the 2016 European Society of Gastrointestinal and Abdominal Radiology (ESGAR) consensus meeting. Eur Radiol 28:1465–1475

10. D’Orsi CJ, Kopans DB (1997) Mammography interpretation: the BI-RADS method. Am Fam Physician 55:1548–1550 1552

11. Barentsz JO, Richenberg J, Clements R et al (2012) ESUR prostate MR guidelines 2012. Eur Radiol 22:746–757

12. Aiken AH, Rath TJ, Anzai Y et al (2018) ACR Neck Imaging Reporting and Data Systems (NI-RADS): a white paper of the ACR NI-RADS Committee. J Am Coll Radiol 15:1097–1108

13. Mitchell DG, Bruix J, Sherman M, Sirlin CB (2015) LI-RADS (Liver Imaging Reporting and Data System): summary, discussion, and consensus of the LI-RADS Management Working Group and future directions. Hepatology 61:1056–1065

14. Ryu KH, Lee KH, Ryu J et al (2016) Cervical Lymph Node Imaging Reporting and Data System for ultrasound of cervical lymphadenopathy: a pilot study. AJR Am J Roentgenol 206:1286–1291

15. Chung MS, Choi YJ, Kim SO et al (2019) A scoring system for prediction of cervical lymph node metastasis in patients with head and neck squamous cell carcinoma. AJNR Am J Neuroradiol 40:1049–1054

16. He N, Xie C, Wei W et al (2012) A new, preoperative, MRI-based scoring system for diagnosing malignant axillary lymph nodes in women evaluated for breast cancer. Eur J Radiol 81:2602–2612

17. Padhani AR, Lecouvet FE, Tunariu N et al (2017) METastasis reporting and data system for prostate cancer: practical guidelines for acquisition, interpretation, and reporting of whole-body magnetic resonance imaging-based evaluations of multiorgan involvement in advanced prostate cancer. Eur Urol 71:81–92

18. McMahon CJ, Rofsky NM, Pedrosa I (2010) Lymphatic metastases from pelvic tumors: anatomic classification, characterization, and staging. Radiology 254:31–46

19. Kim JH, Beets GL, Kim MJ, Kessels AGH, Beets-Tan RGH (2004) High-resolution MR imaging for nodal staging in rectal cancer: are there any criteria in addition to the size? Eur J Radiol 52:78–83
20. Eisenhauer EA, Therasse P, Bogaerts J et al (2009) New response evaluation criteria in solid tumours: revised RECIST guideline (version 1.1). Eur J Cancer 45:228–247

21. Hoang JK, Vanka J, Ludwig BJ, Glastonbury CM (2013) Evaluation of cervical lymph nodes in head and neck cancer with CT and MRI: tips, traps, and a systematic approach. AJR Am J Roentgenol 200:W17–W25

22. Hosten N, Stroszcynski C, Rick O, Lemke M, Felix R (1999) Retroperitoneal recurrence of non-seminomatous testicular tumors: computerized tomography findings before retroperitoneal lymph node excision. Rofo 170:61–65

23. Patel MR, Hudgins PA, Beitler JJ et al (2018) Radiographic imaging does not reliably predict macroscopic extranodal extension in human papilloma virus-associated oropharyngeal cancer. ORL J Otorhinolaryngol Relat Spec 80:85–95

24. Schwartz LH, Bogaerts J, Ford R et al (2009) Evaluation of lymph nodes with RECIST 1.1. Eur J Cancer 45:261–267

25. Seymour L, Bogaerts J, Perrone A et al (2017) iRECIST: guidelines for response criteria for use in trials testing immunotherapeutics. Lancet Oncol 18:e143–e152

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