



Classification of ultrasound features of superficially located lymph nodes

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Assessment of lymphatic drainage areas is a critical task in ultrasound (US) examination of organs and tissues involved in various pathological processes. Superficially located lymph nodes (LNs) are more accessible for US evaluation. The numerous LN changes identified in ultrasound often are challenging for interpretation. The proposed classification provides grading of the detected ultrasound features in superficial LNs into groups, facilitating a risk stratification system for LN malignancy.

Objective. To stratify LN ultrasound features according to the degree of deviation from the normal pattern – from loss of benign features to appearance of signs of malignancy – and to establish a classification of changes in superficially located LN based on US findings.

Results. The classification comprises six levels: normal/unchanged LNs; probably benign LN changes; indeterminate/uncertain LN changes; suspicious LN changes; highly suspicious LN changes; morphologically confirmed malignant LN.

Conclusion. The presented Russian classification for risk stratification of malignancy in superficial LNs will enable a more accurate US assessment of superficial lymph nodes, allowing identification of distinct types of ultrasound structure and selection of suspicious lymph nodes for biopsy.

Keywords: ultrasound; lymph nodes; Node RADS

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INTRODUCTION

Evaluation of lymphatic drainage zones is an essential component of ultrasound examination (US) of organs and tissues involved in various pathological processes. Lymph nodes (LNs) function to prevent the spread of infectious and oncological processes. Acting as biological filters, they cleanse the lymph passing through them from affected organs and tissues. Consequently, the assessment of LN status is of paramount clinical importance, particularly in oncology, as it serves as a criterion for cancer staging and is an essential component in developing a patient's treatment strategy, including the extent of surgical inter-

vention. Both initial assessment and dynamic monitoring to evaluate the response to ongoing conservative therapy are crucial. The role of US in detecting LN alterations, especially in superficial locations, is difficult to overstate in this context, a fact that has been repeatedly emphasized in Russian clinical practice guidelines for the diagnosis and treatment of lymphoproliferative and inflammatory diseases, as well as malignant lesions of the pelvic organs, oropharynx, skin, etc. [1–5].

A standardized US protocol for superficial LNs has been established [6]. The objective of modern US of superficial LNs is not limited to the detection of the node itself but requires its evaluation

based on a specific set of criteria and, where possible, a differential diagnosis of the changes that have altered its architecture to determine the necessity of a biopsy. The difficulty lies in the fact that LNs possess slightly different baseline characteristics across different anatomical regions; moreover, the same criterion may indicate benign processes in one region and malignant processes in another.

All superficial LNs, categorized by lymph outflow direction, can be divided into three major groups [7]:

- Head and neck LNs;
- Thoracic and upper extremity LNs;
- Lower extremity and inguinal LNs.

Each region requires a specific US technique for evaluating lymphatic drainage zones. Simultaneously, the size and architecture of LNs may differ between normal and pathological states: a normal feature in one group may appear suspicious in another. It is precisely the diversity of sonographic appearances of LNs, both in normal conditions and in various pathological processes, that frequently complicates image interpretation for researchers. A classification system is required to categorize the identified US criteria for their systematization and the subsequent development of a risk-stratification system for malignant involvement of superficial LNs.

Radiology reporting and Archiving data systems (RADS), which allow for the stratification of malignancy signs in focal lesions of various organs, have proven highly effective in practice and are actively utilized by all global medical communities, including in Russia. All these classifications are based on lesion detection, assessment according to a specific set of criteria, and the unification of terminology; they stratify identified signs of indeterminate/malignant nature by category. The primary objective is to assist physicians in selecting targets for biopsy and to develop patient management algorithms within an interdisciplinary framework. In ultrasound, classifications based on the stratification of US criteria for breast lesions (BI-RADS), thyroid nodules (TI-RADS), ovarian lesions (O-RADS), etc., have become widespread [8–10]. In oncology, the search for primary tumor is invariably accompanied by the evaluation of regional lymphatic drainage zones.

The known Node-RADS classification, based on the standardized assessment of LNs via computed tomography and magnetic resonance imaging [11], cannot be applied to US, as this modality has its own specific features regarding the orientation

of scanning planes, measurement of identified objects, and the formation and interpretation of US structures. Correlation with the patient's age, clinical presentation, and medical history (primarily oncologic history), as well as the comparison of disease history with the US appearance of the detected LNs, is mandatory.

To date, classifications for US data of superficially located LNs based on individual anatomical zones and various US criteria characterizing uninvolvement and metastatically involved LNs have been proposed in global practice [12–16], most comprehensively presented in the published consensus opinion of the Vulvar International Tumor Analysis (VITA) Group [17]. The number of suggested categories in the presented classifications ranges from 3 to 6.

The proposed classification herein contains six levels/grades of superficial LN status:

- Normal/Unchanged LNs;
- Likely benign LN changes;
- Indeterminate/Uncertain LN changes;
- Suspicious LNs;
- Highly suspicious LNs;
- LNs with morphologically confirmed malignancy requiring dynamic monitoring during treatment.

CLASSIFICATION OF ULTRASONOGRAPHIC CHANGES IN SUPERFICIAL LYMPH NODES

Category LN1 Normal/Unchanged Superficial Lymph Nodes

Shows all ultrasound features characteristic of an unchanged lymph node [18, 19] – LN1 (Fig. 1).

1. Quantity in a single anatomical zone/level: solitary.
2. Dimensions within normal limits (according to anatomical affiliation).

Head and Neck [20–24]

Assessment of the short-axis diameter is considered informative; it depends on the LN localization:

- Facial, parotid, occipital, etc. (head region): ≤ 0.5 cm;
- Cervical LNs are described by levels (Fig. 1) [25, 26]:
 - Levels I, III–VI(VII): < 0.6 cm;
 - Level II: < 0.8 cm.



Fig. 1. Normal US appearance of LNs (indicated by arrows) with preserved structural differentiation: regular shape, smooth and well defined margins. **a** – cervical; **b** – axillary; **c** – inguinal.

The normal ratio of the thickness of the hypoechoic peripheral zone to the central hyperechoic zone is 1:2.

Axillary Regions [12, 27, 28]

Assessment of the cortical thickness is considered informative (measured on the side nearest to the transducer).

Normal cortical thickness: ≤ 0.3 cm.

Supraclavicular and Infraclavicular LNs

Visualization is possible using high-frequency transducers.

They must exhibit the complete set of features of an uninvolved LN.

Short-axis diameter in normal: ≤ 0.5 cm [29, 30].

Inguinal Regions [19, 31–33]

The following parameters are considered informative:

- Short-axis diameter in normal conditions: < 1.5 cm;
- Cortical thickness in normal conditions: ≤ 0.3 cm.
- 3. Shape: regular oval (flat, ovoid).
- 4. L/S ratio: ≥ 2 .
- 5. Borders: sharp.
- 6. Contours: smooth, mildly undulating.
- 7. Differentiation of LN components: preserved, clearly traceable.
- 8. Architecture: unaltered.
- 9. Cortex: uniform thickness (in accordance with anatomical regional norms) and echogenicity.
- 10. Vascular pattern: normal (a-, or hypovascular).
- 11. Flow type: hilar.

Category LN2

Likely Benign LN Changes (Fig. 2–4) in patients presenting with symptoms characteristic of an acute inflammatory process and without a history of malignancy

Criteria deviating from Category 1 are added – LN2:

1. Quantity: **variable** (within a single anatomical zone/level);
2. Dimensions: **variable**;
3. Shape: regular oval (flat, ovoid) or **round**;
4. Borders: sharp;
5. Contours: smooth/mildly undulating/**lobulated**;
6. Differentiation of LN components: preserved or **not defined in B-mode**, but in Color/Power Doppler mode, it correlates with the visualization of a single vessel in the hilum — with preserved hilar (hiliary) vascularity;
7. Cortex: not thickened or **thickened uniformly/non-uniformly, with non-uniformly decreased echogenicity**;
8. Architecture: unaltered or **altered with hypoechoic foci**;
9. Vascularity: variable – a-, hypo-, or **hypervascular**;
10. Flow type: hilar.

Normalization of the US appearance is expected following the cessation of the negative stimulus. The timeframe for short-term follow-up is determined by the managing clinician. Upon follow-up, normalization of the US appearance allows for downgrading to Level 1; persistence or negative dynamics warrants upgrading to higher levels.

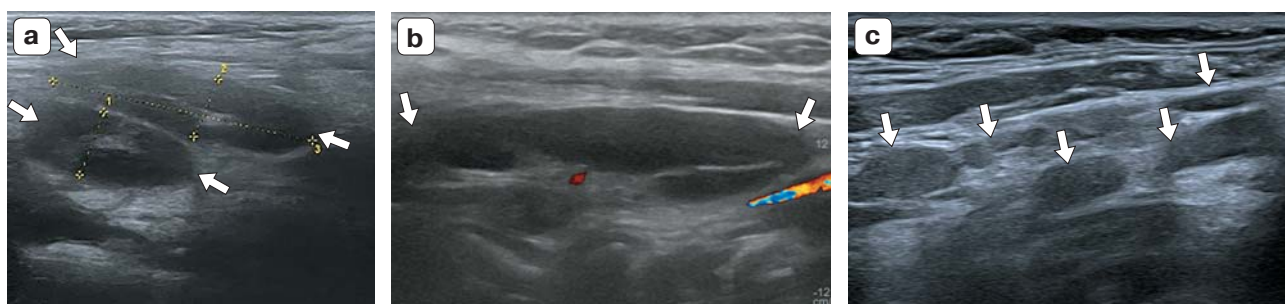


Fig. 2. Reactive LN changes (indicated by arrows) in viral infection. **a, b** — ovoid LNs with increased cortical thickness, hypovascular (c). Multiple hypoechoic LNs arranged in a chain, varying in size and shape (ovoid and round).

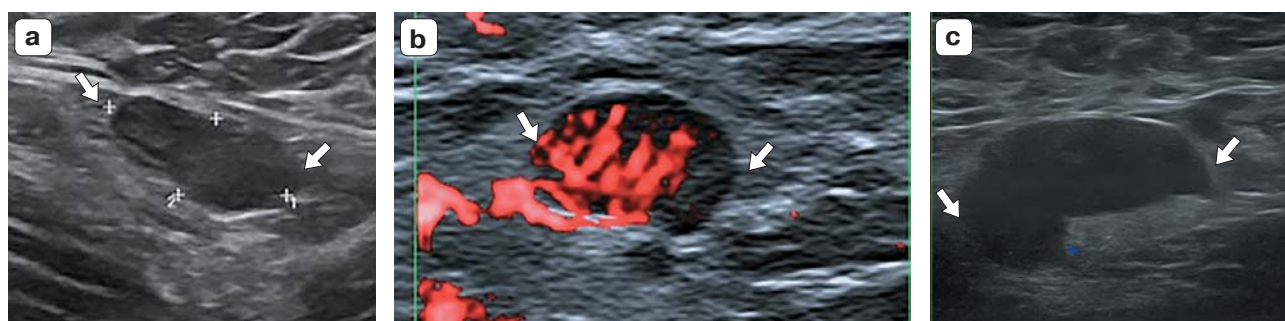


Fig. 3. Reactive changes in LNs (indicated by arrows) in bacterial infection. **a** — LN is almost entirely hypoechoic; **b** — increased vascularization of LN (power Doppler mode). Hilar blood flow pattern; **c** — cortex is uniformly thickened, with markedly hypoechoic. Hypovascularization of LN in Color Doppler. Hilar blood flow pattern.

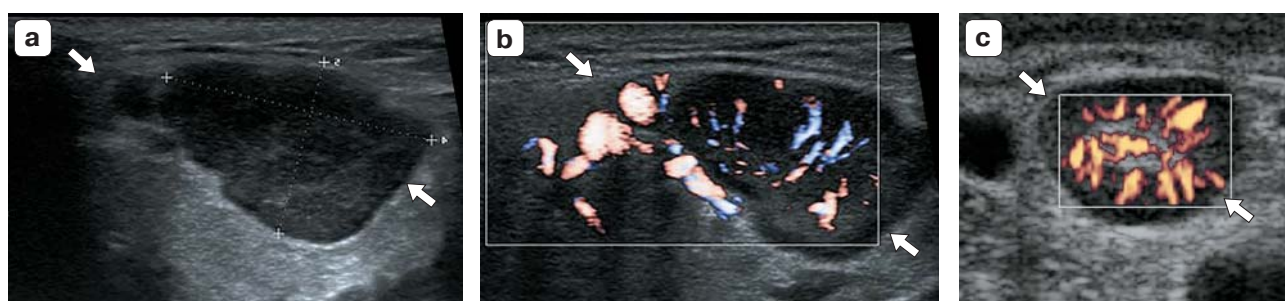


Fig. 4. Acute lymphadenitis of cervical LNs (indicated by arrows). **a, b** — absence of structural differentiation of LN. Inhomogeneous hypoechoic; **b** — increased vascularization of LN (Color Doppler). Hilar blood flow pattern; **c** — LN structural differentiation is preserved; cortex is irregularly thickened. Increased vascularization of LN (power Doppler). Hilar blood flow pattern.

Category LN3

Indeterminate/Uncertain LN Changes (Fig. 5–7) in patients with a history of malignancy presenting with symptoms of an acute inflammatory process, or in patients without symptoms of an acute inflammatory process.

Ultrasound criteria of Level 2, adjusted for clinical presentation and history – LN3.

The timeframe for short-term follow-up is determined by the managing clinician. Upon follow-up, normalization of the US appearance allows for downgrading to LN1; persistence or negative dynamics warrants upgrading to higher levels.

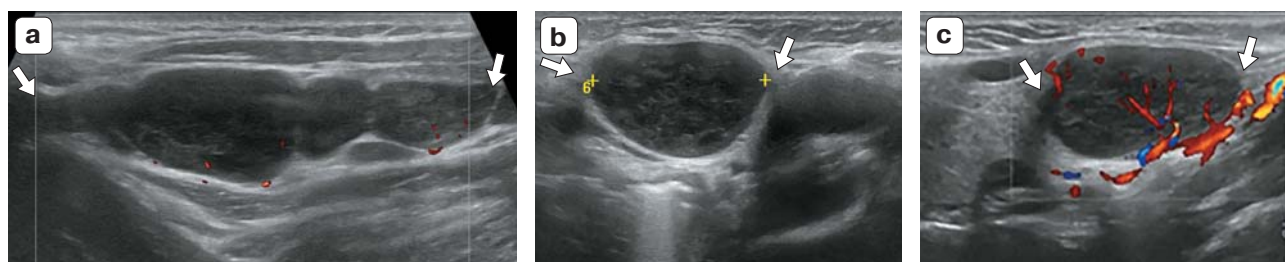


Fig. 5. Reactive changes of LNs (indicated by arrows) – histiocytosis. **a** – inhomogeneous marked hypoechogenicity of LN, impaired differentiation; **b** – LN is hypovascular (color Doppler). Hilar blood flow pattern (power Doppler).



Fig. 6. Reactive changes in LNs (indicated by arrows) in Castleman disease. **a, b** – round shaped LNs, impaired differentiation, marked hypoechogenicity; **c** – LN is hypovascular (color Doppler). Hilar blood flow pattern.

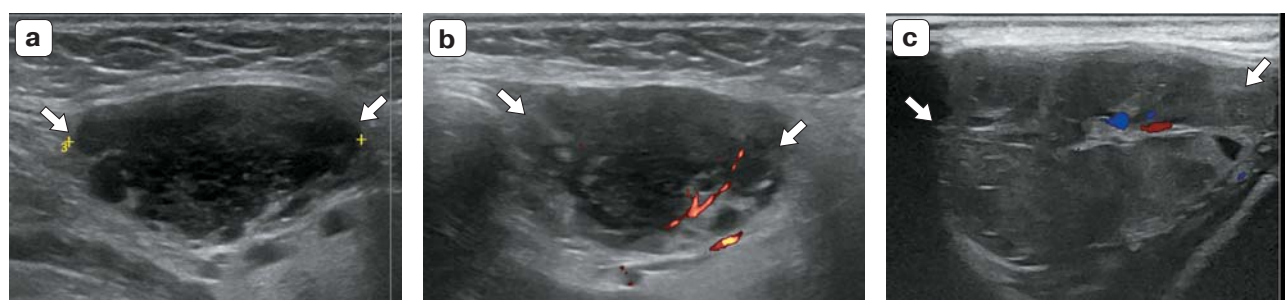


Fig. 7. Chronic lymphadenitis. **a, b, c** – LNs of regular shape. Differentiation of LN structure is unclear. LN echogenicity is irregularly reduced. **b, c** – LNs are hypovascularized with hilar flow pattern (**b** – power Doppler, **c** – color Doppler).

Category LN4

Suspicious LN Changes (Fig. 8, 9):

1. Quantity: variable (solitary, multiple, including those arranged in “packets” without a tendency to coalesce), multi-zonal involvement may be present;

2. Dimensions: variable;

3. Shape: oval/ovoid or round;

4. Borders: sharp;

5. Contours: (ir)regular, lobulated;

6. Differentiation: **not visible in B-mode, and no vessels are identified within the hilum in Color/Power Doppler mode;**

7. Cortex: thickened uniformly or **non-uniformly**, of non-uniformly decreased echogenicity;

8. **Overall LN echogenicity: decreased** (in the absence of differentiation);

9. Architecture: heterogeneous, with hypo-echoic foci, “reticular/net-like”;

10. Vascularity: variable: a-, hypo-, or hyper-vascular;

11. Flow type: **any**.

Suspicion of lymphoproliferative or metastatic LN involvement [10, 12, 19, 33–45].

Histological assessment of the LN is indicated (the biopsy technique is selected by the managing clinician).

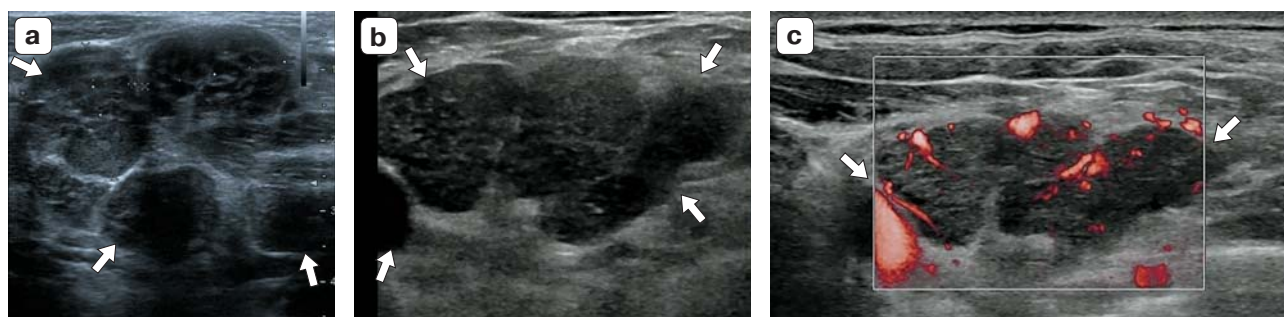


Fig. 8. Alterations in the US pattern of LNs (indicated by arrows) in lymphoproliferative disorders: multinodular involvement; LNs clustered into “packs”; variable shape and size, “reticular” structure, moderate peripheral vascularization.



Fig. 9. Similar US patterns of LNs (indicated by arrows) in lymphoproliferative disorders (a, b) and metastatic involvement (c): enlargement along the short axis, cortical thickening.

Category LN5

Highly Suspicious LN Changes

LNs exhibit the appearance of metastatic involvement (Fig. 10):

1. Quantity: variable (solitary, multiple, including conglomerates);
2. Dimensions: variable;
3. Shape: oval/ovoid, round, or irregular;
4. Borders: (in)distinct;
5. Contours: (ir)regular, nodular, angular/spiculated;
6. Differentiation of LN components: not visible in B-mode, and no vessels are identified within the hilum in Color/Power Doppler mode;
7. Architecture: altered, heterogeneous with anechoic, hyperechoic foci, and calcifications;
8. Overall LN echogenicity: decreased, increased, or isoechoic to surrounding tissues (in the absence of differentiation);
9. Architecture: heterogeneous with an-, hypo-, or hyperechoic punctate foci, including calcifications;
10. Vascularity: variable: a-, hypo-, or hypervascular;
11. Flow type: any.

Based on US findings, metastatic LN involvement is the more likely etiology.

Histological assessment of the LN is indicated (the biopsy technique is selected by the managing clinician).

Category LN6

Morphologically Proven Malignant LN Changes (patient management is determined by the managing clinician).

Any US appearance of the LN (LN2–5) in the context of a proven malignancy.

Dynamic monitoring during therapeutic interventions [46, 47].

The timeframe for follow-up during treatment is determined by the managing clinician. Changes in the US appearance of LNs during treatment may be either positive or negative, which must be documented for the correct evaluation of the ongoing therapy [48–55]. The category, however, remains unchanged.

• Positive dynamics in involved LNs (Fig. 11):

- Absence or reduction in the number of previously visualized LNs;
- Reduction in LN dimensions;
- Change in LN shape (reduction of the short-axis diameter);
- Change in LN architecture (increase in echogenicity, restoration of normal architecture, appearance of necrotic areas as fluid-filled zones);
- Change in LN conglomerate architecture (disappearance of the conglomerate or its "disintegration" into individual LNs);
- Decrease in LN vascularity.

• Negative dynamics in involved LNs (Fig. 12):

- Increase in the number of involved LNs or appearance of new ones;



Fig. 10. Metastatic LNs (indicated by arrows). All LNs show loss of differentiation. **a** – irregular shape; irregular, angular margins; marked reduction in echogenicity. LN is avascular (color Doppler); **b** – irregular round shape, irregular margins, anechoic and punctate hyperechoic foci within the LN structure. Overall LN echogenicity is increased; **c** — ovoid shape, increased echogenicity, anechoic and hyperechoic foci in the LN structure.

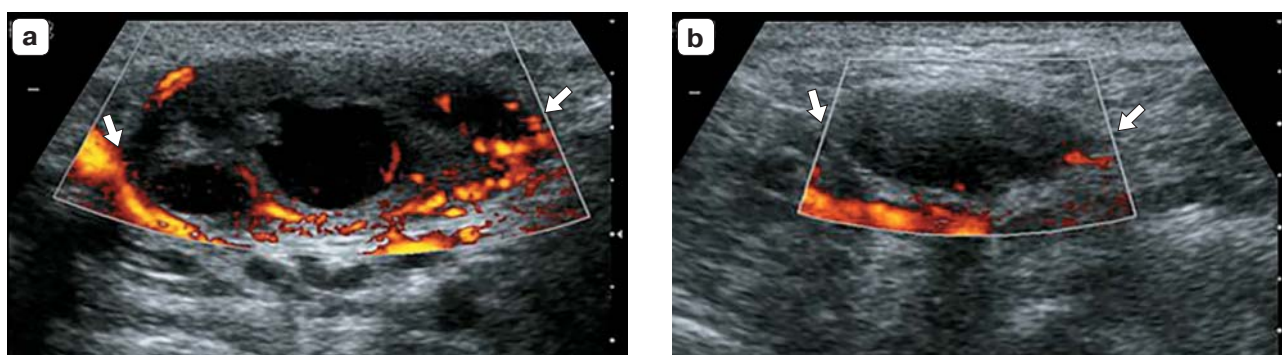


Fig. 11. Dynamic US follow up of a cervical LN (indicated by arrows). **a** – metastatic LN after the first course of chemotherapy. Echogenicity is markedly reduced, differentiation is impaired. Mixed flow pattern. A fluid inclusion is detected within the LN. The LN is moderately vascularized (power Doppler); **b** – positive dynamics after completion of treatment. The LN has decreased in size. Echogenicity has increased. No fluid inclusions are detected. Vascularization has decreased – only a few vascular loci are present (power Doppler).

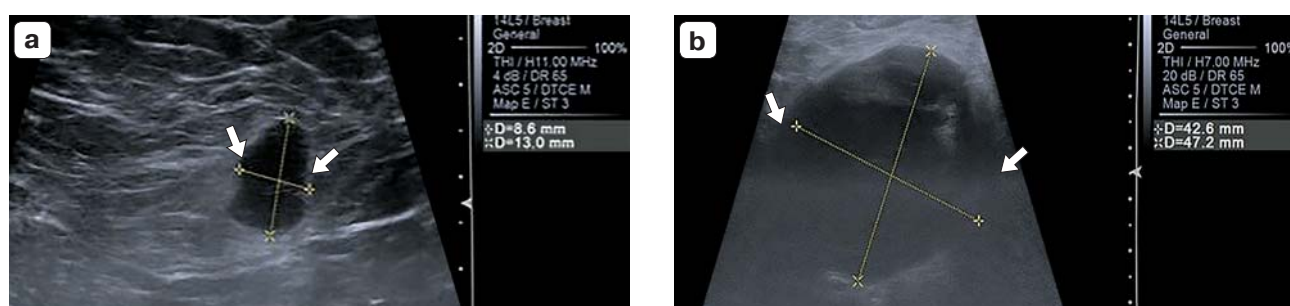


Fig. 12. Dynamic US follow up of an axillary LN (indicated by arrows). **a** – melanoma metastasis. Size: 8.6 × 13.0 mm. Ovoid shape, irregular margins, markedly reduced echogenicity, loss of differentiation; **b** – negative dynamics in the LN under ineffective chemotherapy – increase in size to 42.6 × 47.2 mm.

- Increase in LN dimensions;
- Change in shape (acquiring round/irregular contours);
- Change in LN contours (indistinctness, nodularity, angularity);
- Change in LN architecture (decrease in echogenicity, appearance of marked heterogeneity);
- Coalescence of LNs with the formation of a multinodular conglomerate;
- Increase in vascularity;
- Formation of peripheral or mixed flow types.

Statistical calculations of expert rating agreement for the proposed classification were per-

formed [56] using the Fleiss' kappa criterion via an online kappa calculator. The rate of complete expert agreement was 60.19%; Free-marginal kappa = 0.50; 95% CI [0.41; 0.60]; Fixed-marginal kappa = 0.49; 95% CI [0.45; 0.52]. The analysis results demonstrated good expert rating agreement.

The LN classification is a dynamic system. During practical application, as well as with the emergence of new US techniques and new US criteria for LN description, certain refinements and additions may be made to this initial version of the classification (see Table).

Table. LN classification

LN Category	LN Status	Target Population / Anatomical Scope	Sonographic Criteria	Recommended Action
1	Normal/Unchanged LNs	Regardless of location, patient's condition, or history (including oncologic history), all features of an uninvolved LN are present	Dimensions: N (region-specific) Shape: Regular Borders: Sharp, smooth. Differentiation: Preserved Vascularity: Normal. Flow type: Hilar	No follow-up required
2	Likely benign LN changes Normalization of the US appearance is expected following the cessation of the negative stimulus	Patients presenting with symptoms of an acute inflammatory process and without a history of malignancy	Individual criteria of LN1 + atypical normal variant Quantity and dimensions: Variable. Shape: May be round. Contours: May be lobulated. Differentiation: May not be defined in B-mode. Cortex: May be thickened. Architecture: (Un)altered. Vascularity: Variable. Flow type: Hilar	Follow-up timeframe is determined by the managing clinician
3	Indeterminate/Uncertain LN changes	Patients with a history of malignancy presenting with symptoms of acute inflammation; Patients without a history of malignancy, without symptoms of acute inflammation.	US criteria of LN 2	Short-term follow-up. Timeframe is determined by the managing clinician
4	Suspicious LN changes	Regardless of location, patient's condition, or history (including oncologic history)	Quantity: Variable, including "packets" Dimensions: Variable Shape: Round, oval Borders: Sharp Differentiation: Preserved or absent Architecture: Heterogeneous, may be reticular Vascularity and flow type: Variable	Biopsy. Biopsy technique is selected by the managing clinician.
5	Highly suspicious LN changes	Regardless of patient's location, condition, or history (including oncologic history)	Quantity: Variable, including "conglomerates" Shape: Spherical, irregular Contours: Nodular, spiculated Differentiation: Absent Echogenicity: Variable: with an-, hyperechoic foci, including calcifications Vascularity: Variable Flow type: Peripheral, mixed, or chaotic	Biopsy. Biopsy technique is selected by the managing clinician
6	Morphologically proven malignant LN changes		US appearance of the LN may be any (LN2–5).	Dynamic assessment of LNs during therapy.

CONCLUSION

The presented classification of ultrasound features of superficial lymph nodes will enable a more qualitative assessment of superficial lymph nodes during US examinations. It allows for the differentiation of specific types of alterations in their ultrasound architecture and facilitates the selection of suspicious lymph nodes for biopsy.

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Классификация изменений ультразвуковых признаков поверхностно расположенных лимфатических узлов

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Оценка состояния зон лимфооттока является важной задачей ультразвукового исследования (УЗИ) органов и тканей, вовлеченных в разнообразные патологические процессы. Для изучения с помощью УЗИ более доступны поверхностно расположенные лимфатические узлы (ЛУ). Выявленные многочисленные изменения ЛУ достаточно часто вызывают затруднения при их интерпретации. Предложенная классификация позволяет провести градацию выявленных ультразвуковых критериев изменения поверхностных ЛУ на группы для дальнейшего формирования системы стратификации риска злокачественных поражений ЛУ.

Цель исследования: провести градацию ультразвуковых критериев лимфатических узлов по уровням их отклонения от неизменных, теряющих доброкачественные признаки, до приобретающих признаки злокачественности и сформировать классификацию изменений поверхностно расположенных лимфатических узлов по данным УЗИ.

Результаты. Классификация включает 6 уровней: нормальные/неизменные ЛУ; вероятно, доброкачественные изменения ЛУ; сомнительный/неопределенный характер изменений ЛУ; подозрительный характер изменений ЛУ; высокоподозрительный характер изменений ЛУ; морфологически подтвержденный злокачественный характер изменений ЛУ.

Заключение. Представленная российская классификация стратификации риска злокачественности поверхностных ЛУ позволит более качественно оценивать поверхностные лимфатические узлы в ходе выполнения УЗИ, выделяя отдельные типы изменений их ультразвуковой структуры, и проводить отбор подозрительных ЛУ для выполнения биопсии.

Ключевые слова: ультразвуковое исследование; лимфатические узлы; Node-RADS

Конфликт интересов. Авторы заявляют об отсутствии возможных конфликтов интересов.

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