

# Terms, definitions and measurements to describe sonographic features of lymph nodes: consensus opinion from the Vulvar International Tumor Analysis (VITA) group

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**KEYWORDS:** diagnostic imaging; groin; lymph nodes; ultrasonography; vulvar neoplasm

## ABSTRACT

*In centers with access to high-end ultrasound machines and expert sonologists, ultrasound is used to detect metastases in regional lymph nodes from melanoma, breast cancer and vulvar cancer. There is, as yet, no international consensus on ultrasound assessment of lymph nodes in any disease or medical condition. The lack of standardized ultrasound nomenclature to describe lymph nodes makes it difficult to compare results from different ultrasound studies and to find reliable ultrasound features for distinguishing non-infiltrated lymph nodes from lymph nodes infiltrated by cancer or lymphoma cells. The Vulvar International Tumor Analysis (VITA) collaborative group consists of gynecologists, gynecologic oncologists and radiologists with expertise in gynecologic cancer, particularly in the ultrasound staging and treatment of vulvar cancer. The work herein is a consensus opinion on terms, definitions and measurements which may be used to describe inguinal lymph nodes on grayscale and color/power Doppler ultrasound. The proposed nomenclature need not be limited to the description of inguinal lymph nodes as part of vulvar cancer staging; it can be used to describe peripheral lymph nodes in general, as well as non-peripheral (i.e. parietal or visceral) lymph nodes if these can be visualized clearly. The association between the ultrasound features described here and*

*histopathological diagnosis has not yet been established. VITA terms and definitions lay the foundations for prospective studies aiming to identify ultrasound features typical of metastases and other pathology in lymph nodes and studies to elucidate the role of ultrasound in staging of vulvar and other malignancies. © 2021 International Society of Ultrasound in Obstetrics and Gynecology.*

## INTRODUCTION

The aim of preoperative imaging in patients with histologically proven vulvar cancer is to detect macroscopic metastases in lymph nodes. Finding small-volume metastases, or micrometastases, using any type of imaging is challenging<sup>1–3</sup>. In gynecologic oncology centers with available ultrasound expertise, ultrasound alone is the method of choice for preoperative assessment of inguinal lymph nodes, with a reported sensitivity of 76–90% and specificity of 60–96%<sup>4–9</sup>. Adding fine-needle-aspiration biopsy does not increase the accuracy, and Garganese *et al.*<sup>9</sup> concluded that ultrasound alone is sufficient for lymph-node staging in vulvar cancer. Even though computed tomography, magnetic resonance imaging and positron emission tomography are recommended in international guidelines<sup>10–13</sup>, their use does not increase detection rates over those of ultrasound alone

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Accepted: 8 February 2021

(Appendix S1)<sup>10,14</sup>. Ultrasound, therefore, being widely available, safe and relatively cheap, should be the method of choice for detecting metastases in inguinal lymph nodes. It offers high diagnostic accuracy with the possibility of ultrasound-guided biopsy. It can also be fused with other imaging modalities, for example with single-photon-emission computed tomography/computed tomography<sup>15</sup>.

There is, as yet, no international consensus on the ultrasound assessment of lymph nodes in any location. The Vulvar International Tumor Analysis (VITA) group was created in 2016, during the 26<sup>th</sup> World Congress on Ultrasound in Obstetrics and Gynecology, in Rome, Italy. Its aim is to provide a consensus opinion on which examination technique, measurement technique and terminology should be used to describe the ultrasound appearance of inguinal lymph nodes in women with vulvar cancer. This VITA consensus opinion has been agreed by all members of the VITA group. It is accompanied by representative ultrasound images, videoclips and schematic images of inguinal lymph nodes. The VITA terms and definitions lay the foundations for prospective studies aiming to identify ultrasound features typical of lymph-node metastases and the role of ultrasound in the staging of vulvar and other malignancies. The agreement between the ultrasound features described in the VITA consensus opinion and histopathological diagnosis has not yet been established.

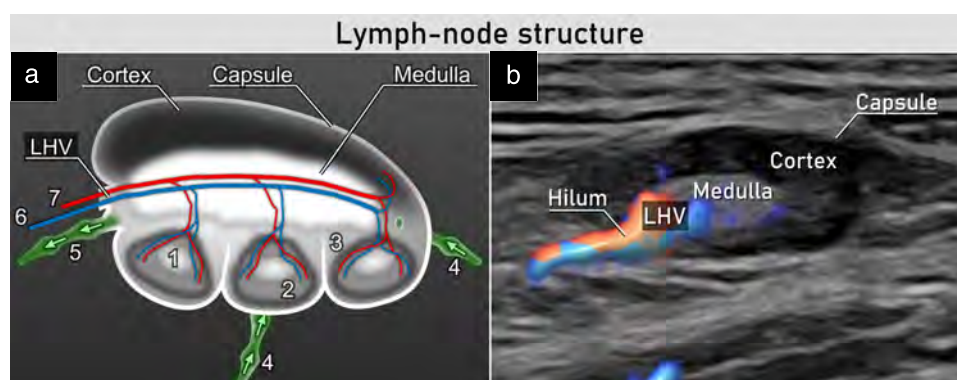
Although this VITA consensus opinion focuses on the assessment of inguinal lymph nodes, the proposed nomenclature may be used for any lymph nodes, not only superficial ones but also those located deeply, if the patient's habitus and the ultrasound technology used allow high-resolution imaging.

This consensus opinion is structured as follows: (1) lymph-node anatomy; (2) ultrasound technique when examining lymph nodes in the groin; (3) VITA terminology for standardized description of lymph nodes in vulvar cancer; and (4) ultrasound characteristics of infiltrated and non-infiltrated lymph nodes (non-infiltrated including normal, reactive and postreactive lymph nodes).

Additional information is available online (Supplementary VITA consensus statement: Appendix S2) and includes the following: (1) general background and detailed description of the lymphatic system; (2) anatomy of the femoral triangle (important for preoperative assessment and description of the precise location of infiltrated lymph nodes); (3) VITA terms, definitions and measurements for description of the ultrasound features of various types of lymph-node pathology; (4) suggested classification of groin lymph nodes as being non-infiltrated or infiltrated by vulvar cancer, based on their ultrasound appearance.

## LYMPH-NODE ANATOMY

Normal lymph nodes are bean-shaped or oval formations with regular contours. They are composed of a dense accumulation of lymphoid tissue enclosed by a capsule of collagen and elastin fibers. Unfiltered lymph enters the node via several afferent lymphatic vessels and drains from the periphery of the node to its center through various paths, finally collecting at the hilum of the lymph node. The lymph is filtered and checked by white blood cells for pathogens, such as bacteria, viruses and cancerous or dead cells, while passing from the subcapsular sinus through numerous radial cortical sinuses to the medullary sinuses. The filtered lymph flows out of the node via efferent lymphatic vessels. The node structure consists of four zones: capsule, cortex, paracortex and medulla (Figure 1, and Figure S2 in Appendix S2). On ultrasound imaging, the lymph node is seen surrounded by a thin hyperechogenic line, corresponding to the capsule. The afferent lymphatic vessels enter the lymph node through the capsule. The cortex is seen as hypoechogenic tissue surrounding the hyperechogenic medulla. The paracortex is the region between the cortex and medulla and is not clearly distinguishable on ultrasound. The hilum is a depression on the side of the lymph node where blood vessels usually enter and leave, and from where the efferent lymphatic vessels leave the lymph node. The supplying arteries and veins, the longitudinal hilar vessels, are detectable



**Figure 1** (a) Schematic diagram of normal lymph node in groin, showing: germinal center (1); subcapsular sinus (2); paracortex with high endothelial venules (3); afferent lymph vessels (4); efferent lymph vessel (5); vein (6); artery (7); longitudinal hilar vessels (LHV). (b) Color Doppler ultrasound image showing capsule, cortex, medulla and LHV entering lymph node at hilum. This normal lymph node has typical oval shape and regular contour, with hilar flow and central hyperechogenic medulla surrounded by thin and homogeneous hypoechogenic cortex.

with color Doppler ultrasound. A detailed description of lymph-node anatomy and function is provided in the supplementary VITA consensus opinion (Appendix S2).

## EXAMINATION METHODOLOGY

Inguinal lymph nodes should be assessed using a high-frequency (7.5–14 MHz) linear-array probe. Ultrasound examination of the inguinal region (femoral triangle) should be performed systematically, by a trained sonographer. Basic knowledge of the anatomy of this region is essential for accurate scanning (Appendix S2 and Videoclips S1 and S2). Three useful steps and landmarks for assessing the femoral triangle using ultrasound are provided in Appendix S3 and tips and tricks for assessing the exact location of inguinal lymph nodes are in Appendix S4.

Evidence is scant regarding the possible value of elastography or contrast-enhanced ultrasound in the assessment of peripheral lymph nodes. Neither of these techniques is recommended for their routine assessment<sup>16,17</sup>.

### Examination steps

The patient is asked to lie in a supine position, with legs extended and apart. The boundaries of the inguinofemoral triangle define the region of interest to be covered during the ultrasound examination (Videoclip S3, Figure 2). The examination starts by sliding the probe from the apex of the triangle in a cranial direction towards the inguinal ligament along the femoral vessels, showing structures in transverse, oblique and longitudinal planes (Appendix S3). The aim is to examine all of the Daseler regions (Appendix S4).

#### Apex of femoral triangle

The probe is oriented in the transverse plane over the femoral vessels at the apex of the femoral triangle. This apex corresponds to the convergence of the sartorius muscle and the adductor longus muscle in the upper third of the anterior thigh. Color Doppler may be used to detect the vessels, if they are not immediately apparent, and the image should be optimized. First, attention is paid to the femoral vein. At the apex of the triangle, the femoral vein lies dorsal to the artery and becomes medial as the probe is moved towards the inguinal ligament. Visualization of the femoral vein (necessary for orientation) could be hindered by excessive compression. Therefore, one should apply only gentle pressure with the probe and move the transducer with slow and controlled movements in order to maintain a good anatomical overview.

#### Common femoral vein

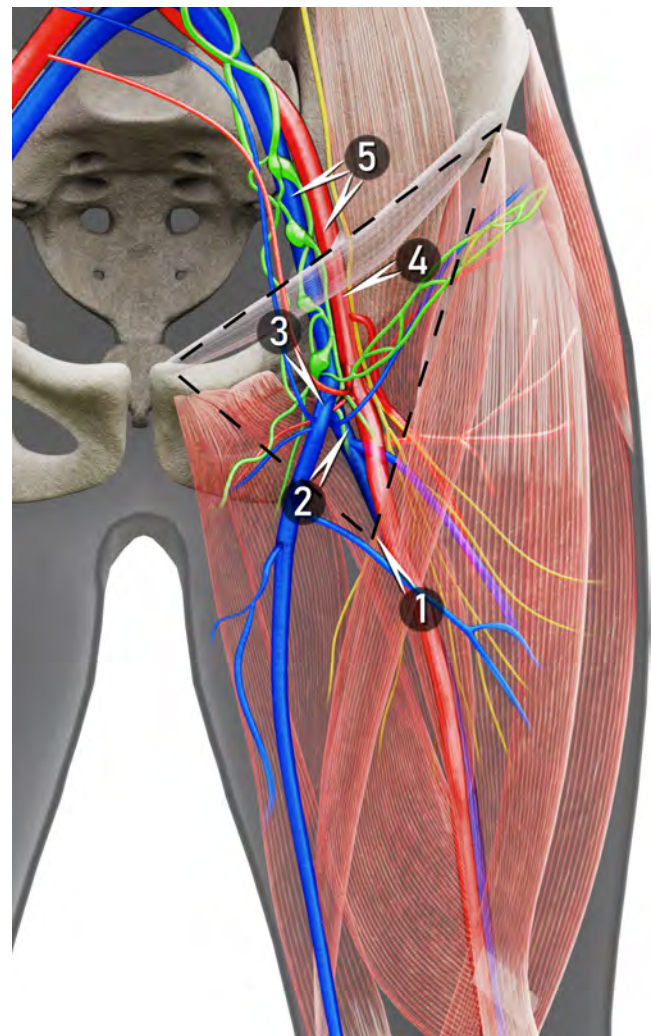
The femoral vein receives the deep femoral vein, which runs alongside the deep femoral artery, and together they form the common femoral vein, which is located medial to the femoral artery. This confluence is distal to the saphenofemoral junction and to the bifurcation of the femoral artery and deep femoral artery.

#### Saphenofemoral junction

The great saphenous vein lies within the subcutaneous tissues and joins the common femoral vein 2.5–3.5 cm beneath the inguinal ligament. There is always a venous valve 1–2 mm distal to the saphenofemoral junction. Having identified the saphenofemoral junction, the course of the great saphenous vein and its tributaries (superficial external pudendal, superficial epigastric and superficial circumflex iliac veins) is followed.

#### Femoral artery

Parallel to the femoral vein runs the femoral artery. At the apex of the triangle, it is located ventral to the vein and becomes lateral as the probe moves cranially. The femoral artery gives rise to the deep femoral artery at the same level as, or close to, the saphenofemoral junction. Proximally, the tiny anterior branches of the femoral artery (superficial external pudendal, superficial epigastric and superficial circumflex iliac artery) run parallel to the



**Figure 2** Schematic diagram representing ultrasound methodology for systematic assessment of anatomic landmarks for nodal vulvar cancer staging. Indicated are: apex of femoral triangle (1); common femoral vein (2); saphenofemoral junction (3); femoral artery (4); external iliac vessels (5). See also Videoclip S3.

horizontal plane under the muscular fascia and, more cranially, at the upper part of the femoral triangle, they move towards the surface, following the course of their corresponding veins.

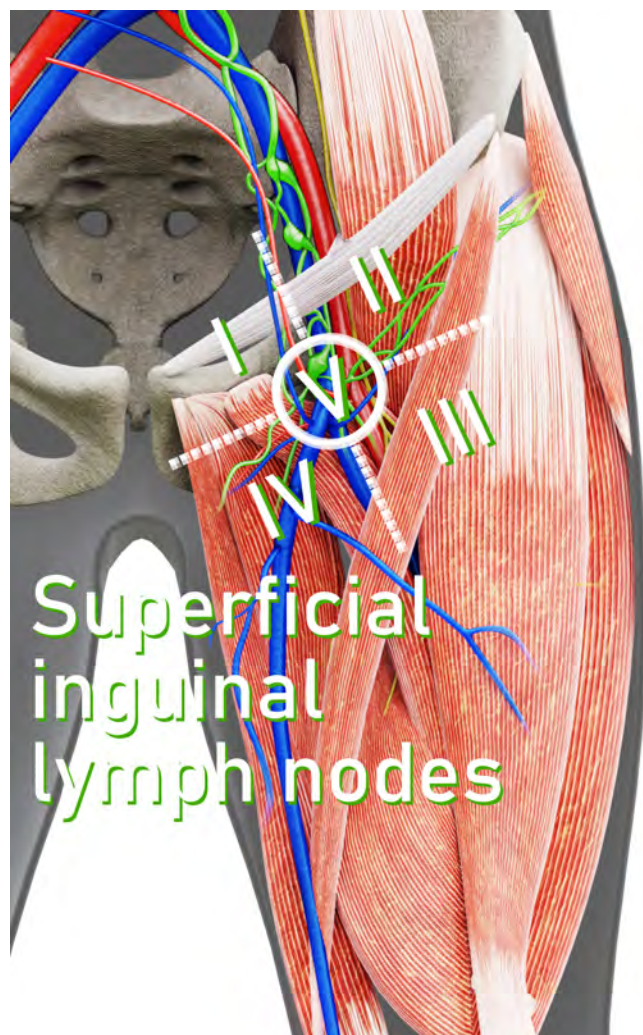
#### *External iliac vessels*

After passing through the vascular lacuna underneath the inguinal ligament, the femoral vein and artery continue as the external iliac vein and artery. The inguinal ligament is a thick and hyperechoic band that appears in an oblique plane when the probe is aligned along a virtual line between the anterior superior iliac spine and the pubic tubercle.

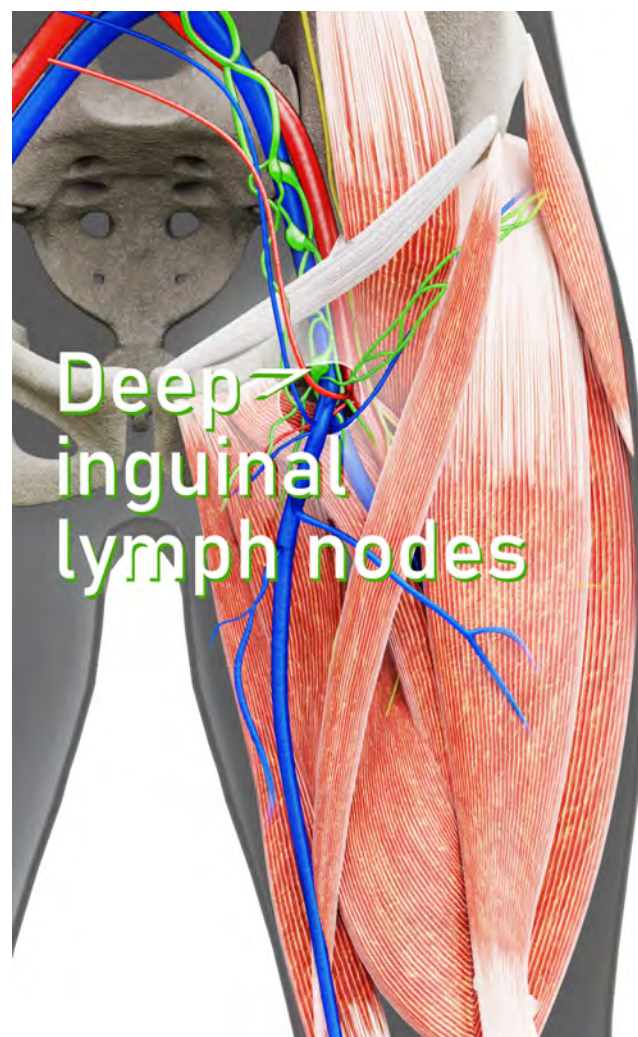
#### *Lymph nodes*

Having established an overview of the inguinal region by identifying the blood vessels, as described above, the lymph nodes are examined. A combination of transverse

and longitudinal planes is used to differentiate the superficial and deep inguinal lymph nodes (Appendix S4). The location of the superficial lymph nodes is described using the Daseler regions (Figure 3). The first region (superomedial region) is crossed by the external pudendal vessels (and sometimes by the superficial epigastric vessels). The second region (superolateral region) is crossed by the superficial circumflex iliac vessels (and sometimes by the superficial epigastric vessels). The third region (inferolateral region) is often free from vascular structures (sometimes, accessory branches of the saphenous vein can be recognized). The fourth region (inferomedial region) is defined by the great saphenous vein. The fifth region (central region) is filled by the saphenofemoral junction. The deep inguinal lymph nodes are always located medial to the common femoral vein and above the caudal margin of the saphenous opening (oval fossa) (Figure 4). It is important to describe the site and size of any lymph node suspected to be infiltrated with tumor, the presence of extranodal extension of tumor and the relation of the affected lymph node to the surrounding vessels, in order to



**Figure 3** Schematic diagram showing Daseler regions in left thigh for describing location of superficial inguinal lymph nodes. Virtual line drawn along femoral vein and second virtual line drawn perpendicular to first line and passing through saphenofemoral junction divide femoral triangle into: superomedial region (I); superolateral region (II); inferolateral region (III); and inferomedial region (IV). Central zone (V) is circled.



**Figure 4** Schematic diagram showing deep inguinal lymph nodes. Arrow points to deep inguinal node medial to femoral vein and cranial to lower margin of oval fossa. Oval fossa is outlined with white circle.

optimize further management, such as ultrasound-guided biopsy, surgery, radiotherapy and follow-up. The target lymph nodes are those manifesting ultrasound features deviating from the normal lymph-node pattern. An example of a standardized report of the results of an ultrasound examination of inguinal lymph nodes in vulvar cancer staging is shown in Appendix S5.

## VITA TERMS, DEFINITIONS AND MEASUREMENTS

Ultrasound examination of inguinal lymph nodes includes both quantitative and qualitative parameters. Each parameter should be assessed in at least two orthogonal planes<sup>9</sup>. The nodes need to be assessed in sufficient detail (high magnification and resolution) while maintaining an overall view of the surrounding perinodal tissue to evaluate reliably certain features, such as grouping or the perinodal ring. The dominant characteristics should be assessed while evaluating each feature in the lymph node, rather than focusing on minute changes.

The VITA terminology can be used for standardized description of any clearly visible lymph node, irrespective of whether or not it is peripheral. The ultrasound appearance of various pathological conditions affecting lymph nodes is described using the VITA terminology in the supplementary VITA consensus opinion (Appendix S2).

### Assessment of lymph-node dimensions

Quantitative assessment is used to define lymph-node size and shape, cortical thickness and uniformity of thickness.

#### *Lymph-node size*

The size of the lymph node is defined by three diameters in two orthogonal planes. The most relevant diameters are length and depth; the transverse diameter is not measured routinely. The long axis (length (L)) is the longest diameter of the lymph node in any plane. The short axis (depth (S)) is the maximum diameter of the lymph node perpendicular to its long axis (Figure 5).

#### *Lymph-node shape (L/S ratio)*

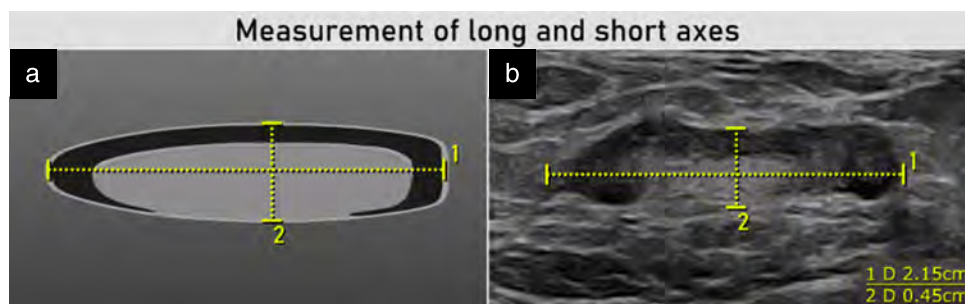
The long-axis-to-short-axis ratio (L/S ratio), also known as the length/depth ratio, is used to define the nodal shape (oval or round) quantitatively. Traditionally, an oval or elliptical shape corresponds to a long axis that is at least two times greater than the short axis ( $L/S \text{ ratio} \geq 2$ ) (Figure 5). In many studies,  $L/S \text{ ratio} \geq 2$  is considered a sign of benign lymph nodes, while metastatic lymph nodes are described as round, with  $L/S \text{ ratio} < 2$ <sup>9</sup>.

#### *Cortical thickening (C/M ratio)*

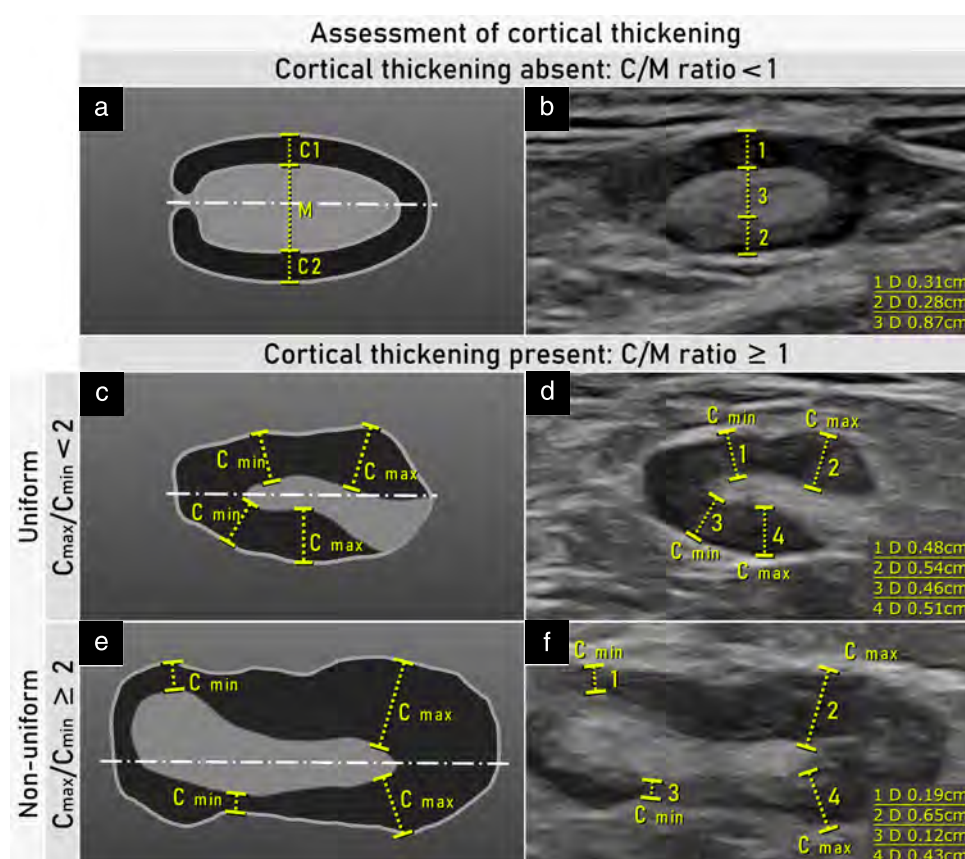
The cortical-thickness-to-medullar-thickness ratio (C/M ratio) is used to define the cortical thickening (Figure 6)<sup>18,19</sup>. The measurements are taken at the widest point of cortical thickening perpendicular to the long axis of the lymph node. The thickness of the cortex is measured from corticomedullar interface to nodal border on both sides, on the same axis. 'Cortical thickening' is defined when the thickness of the cortex is equal to or wider than that of the medulla, when both are measured on the same axis ( $C/M \text{ ratio} \geq 1$ ) (Figure 6).

#### *Uniformity of cortical thickening (Cmax/Cmin)*

Measurements to assess the uniformity of cortical thickening (maximum-cortical-thickness-to-minimum-cortical-thickness ratio ( $C_{\text{max}}/C_{\text{min}}$ )) are taken on the same section as is used to measure cortical thickening. The lymph node is divided by its longest axis into two halves and the uniformity is assessed in each half separately. The thickest cortical diameter ( $C_{\text{max}}$ ) and the thinnest one ( $C_{\text{min}}$ ) are measured perpendicular to the surface of the nodal capsule<sup>2</sup>, from the capsule to the corticomedullar interface, on each side of the lymph node. Uniform cortical thickening is defined as  $C_{\text{max}}/C_{\text{min}} < 2$  on both sides. Non-uniform cortical thickening is defined as  $C_{\text{max}}/C_{\text{min}} \geq 2$  on either or both sides of the lymph node (Figure 6).



**Figure 5** Schematic diagram (a) and ultrasound image (b) of normal lymph node with oval shape, showing measurement of lymph-node long and short axes, taken in plane in which longest nodal diameter is seen. Long axis (length, L; caliper 1) is longest diameter of lymph node, and short axis (depth, S; caliper 2) is maximum diameter perpendicular to long axis. Their ratio (L/S) is calculated as part of quantitative assessment of lymph nodes;  $L/S \text{ ratio} \geq 2$  indicates oval shape, as demonstrated in this case.



**Figure 6** Assessment of lymph-node cortical thickening and its uniformity: schematic diagrams and ultrasound images showing absence (a,b) and presence (c–f) of cortical thickening. First, thickness of cortex (C) is measured on either side of medulla (M), on same axis, perpendicular to long axis of lymph node, in plane in which longest nodal diameter is seen and at point where lymph-node cortex is judged to be at its thickest. Absence of cortical thickening is defined when cortex is thinner than medulla ( $(C1 + C2)/M$  ratio < 1). Cortical thickening is defined when cortex is as wide as, or wider than, medulla ( $(C1 + C2)/M$  ratio  $\geq 1$ ). Second, cortical uniformity is assessed on each side of the lymph node separately, after node is halved along its long axis. Thickest cortical diameter (Cmax) and thinnest one (Cmin) are measured perpendicular to the surface of the nodal capsule, from the capsule to the corticomedullar interface, on each side of the lymph node. Cortical thickening is uniform (c,d) when  $C_{max}/C_{min} < 2$  on both sides. Cortical thickening is non-uniform (e,f) if  $C_{max}/C_{min} \geq 2$  either on one side or on both sides of the lymph node.

## Morphological assessment

### Nodal shape

Shape is a subjective assessment of the lymph-node contour. It can be regular, i.e. oval or round, or irregular (Figure 7, Videoclip S4). Oval lymph nodes have a dominant long axis, while round lymph nodes have long and short axes that are similar in length<sup>20</sup>. Irregular shape means that the outer contour is lobulated or spiculated. Lymph nodes with a lobulated shape have a smooth, wavy external contour and intact capsule. Lymph nodes with a spiculated contour have spiky, blurred margins, often accompanied by capsular interruption.

### Nodal-core sign

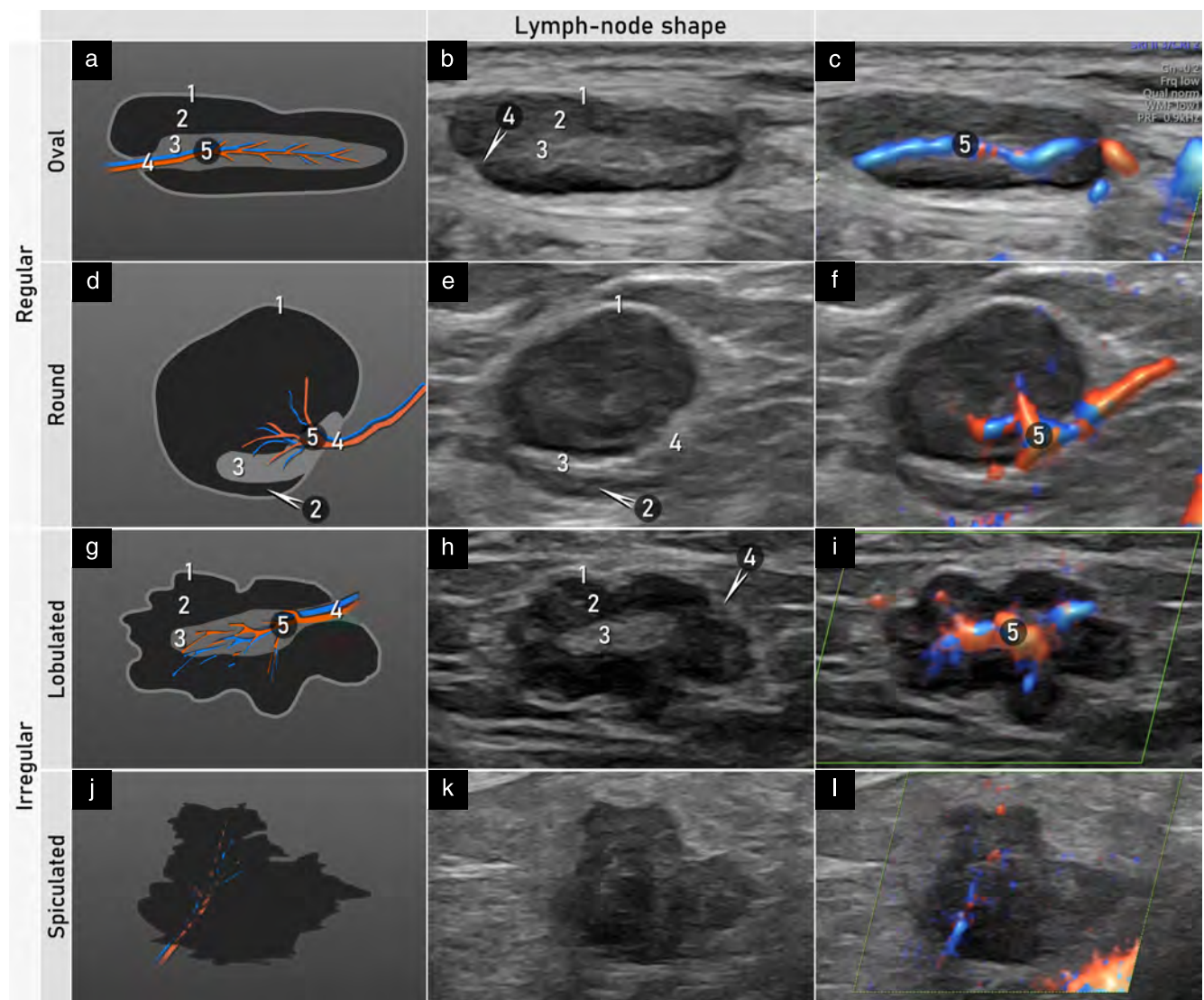
The nodal core is the functional unit formed by the nodal hilum and the medulla. The nodal-core sign is present when the medulla is visible: it is complete when both hyperechogenic hilum and medulla are visible, and partial when the hilum is not detectable but the medulla is visible. The nodal-core sign is absent when neither

hilum nor medulla is present (Figure 8, Videoclip S5). Hilal vascular flow may still be detected even when the hyperechogenic nodal-core sign is absent, as may be seen, rarely, in reactive lymph nodes. Peripheral displacement of the nodal core by a neoplastic process is regarded as the nodal-core sign being present (Figure 7d–f).

### Cortical thickening

It is possible to assess sonographically cortical thickening ( $C/M$  ratio  $\geq 1$ ) only in the presence of a medulla as a reference structure (Figure 6)<sup>21</sup>. The  $C/M$  ratio can be a useful tool with which to assess the cortical thickness in case of diffuse concentric cortical thickening (Figure 6, Appendix S2). Diffuse cortical thickening can be uniform ( $C_{max}/C_{min} < 2$ ) or non-uniform ( $C_{max}/C_{min} \geq 2$ ) (see Assessment of lymph-node dimensions, above). If there is focal cortical thickening, then, by definition, it is non-uniform.

Cortical thickening not only affects the contour of the lymph node, causing outwards bulging, but can also affect the lymph-node structure inwardly, creating convex indentations into the hyperechogenic medulla and leading



**Figure 7** Schematic diagrams and ultrasound images showing four different shapes of lymph node. Indicated are: capsule (1); cortex (2); medulla (3); hilum (4); and longitudinal hilar vessels (5). (a–c) Oval (regular) shape of normal lymph node. Long axis is dominant. (d–f) Round (regular) shape of infiltrated lymph node with intranodal metastasis. Long and short axes are similar in length. (g–i) Lobulated (irregular) shape of reactive lymph node. Cortex has several bulges with concentric non-uniform cortical thickening and smooth outline. (j–l) Spiculated (irregular) shape of lymph node completely infiltrated by cancer. Dominant axis is not assessable. Lymph node has spiculated and blurred edges, with interruption of capsule around it. See also Videoclip S4.

to its asymmetric compression (Figure 9, Videoclip S6). Focal cortical thickening is characterized by outward bulging involving < 50% of the nodal circumference. Diffuse cortical thickening involves 50% or more of the lymph-node circumference and is either concentric or eccentric. Concentric cortical thickening surrounds the centrally placed nodal core. Eccentric cortical thickening bulges not only outwards but also inwards, creating convex indentations into the medulla, and, with careful examination using a linear-array probe, it is possible to see the nodal core displaced towards the periphery<sup>22</sup>.

### Nodal echogenicity

Nodal echogenicity is evaluated in abnormal lymph nodes. The echogenicity of the lymph-node cortex, if the nodal-core sign is present, or of the whole lymph node, if the

nodal-core sign is absent, refers to its sonographic appearance compared with the echogenicity of the adjacent soft tissue. It should be described as homogeneous or non-homogeneous. The type of heterogeneity should be specified, if possible, as follows: focal changes in echogenicity due to hyperechogenic deposits or cystic areas; or a diffuse, non-homogeneous appearance, described as sand pattern or reticulation (Figure 10, Videoclip S7). Sand pattern is characterized by multiple tiny hyperechogenic spots (due to microcalcifications or other pathology) dispersed throughout the node. Reticulation is characterized by thin hyperechogenic lines that separate a hypoechogenic cortical texture, producing a microcystic-like pattern. To define echogenicity, it can be useful to observe posterior changes (enhancement or shadowing) that may appear behind the entire lymph node or behind the single intranodal deposit. When it is not possible to determine a specific

pattern of heterogeneity, the sonographic appearance is described as non-homogeneous indeterminate.

### Capsular interruption

Capsular interruption is the presence of a blurred, interrupted interface between the lymph node and the perinodal tissue and should be reported as being either present or absent (Figure 11, Videoclip S8). In a normal lymph node, the surrounding capsule is smooth and clearly separate from the perinodal tissue<sup>23</sup>. Malignant lymph nodes often maintain smooth borders. Blurred and irregular borders in metastatic lymph nodes indicate extracapsular tumor spread and influence prognosis negatively<sup>9</sup>.

### Distortion of corticomedullar interface

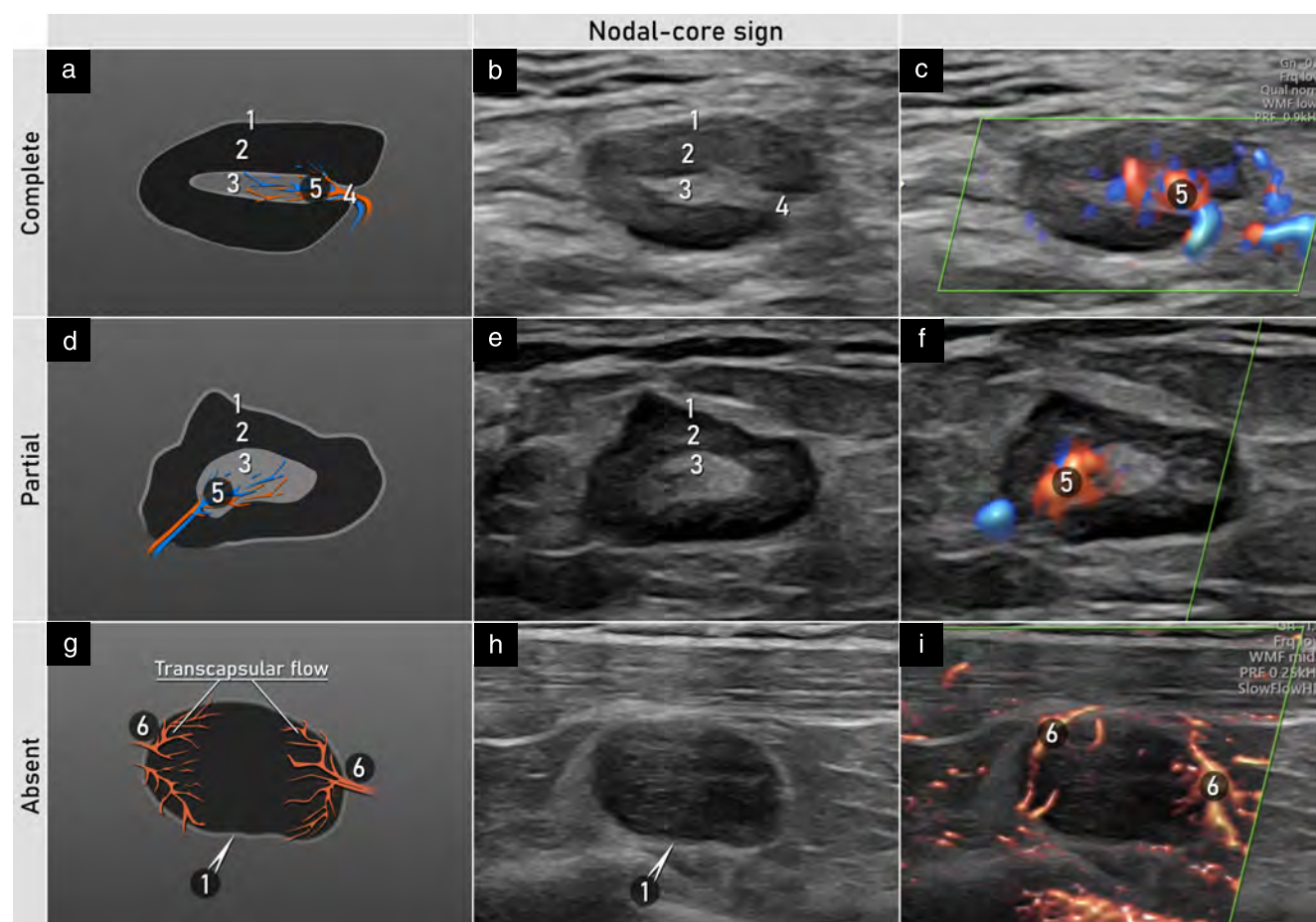
Corticomedullar interface distortion is defined as the lack of smooth and regular borders between cortex and medulla and should be reported as being either present or absent (Figure 12, Videoclip S9). Corticomedullar interface distortion can be assessed sonographically only in the presence of a medulla as a reference structure. When nodal-core sign is absent, it is not possible to determine this feature.

### Perinodal hyperechogenic ring

A hyperechogenic ring is defined as a complete, blurred, thick halo around the infiltrated lymph node, inside which the sharply demarcated, tiny, hyperechogenic septa of the normal perinodal soft tissue are no longer identifiable<sup>24</sup>. It should be reported as being either present or absent (Figure 13, Videoclip S10)<sup>9,25</sup>. The perinodal ring appears due to a desmoplastic perinodal tissue reaction and is usually a sign of infiltrated lymph nodes. Hyperechogenicity of the lymph-node capsule, acoustic enhancement behind the lymph node and hyperechogenic superficial and deep fascia delineating superficial lymph nodes should not be regarded as perinodal hyperechogenic ring. It is impossible to describe the perinodal hyperechogenic ring in static images or clips presenting lymph nodes without sufficient perinodal tissue.

### Grouping of lymph nodes (matting)

Grouping of lymph nodes refers to fusion of individual lymph nodes into an ill-defined mass, sometimes infiltrating, or being fixed to, the surrounding structures. Grouping may be absent or present and, if present, it may be partial or complete (Figure 14, Videoclip S11).



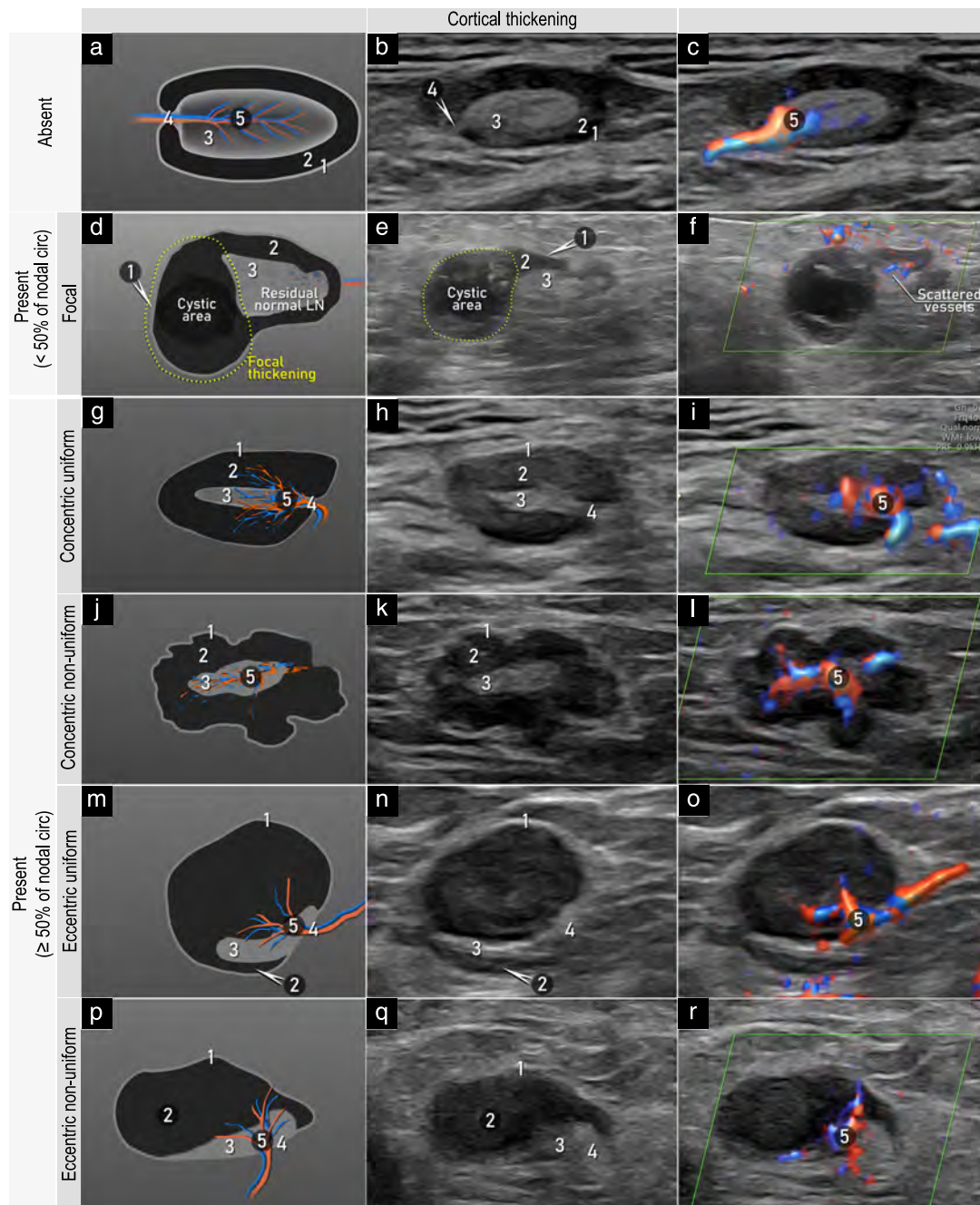
**Figure 8** Schematic diagrams and ultrasound images showing present (complete or partial) and absent nodal-core sign. Indicated are: capsule (1); cortex (2); medulla (3); hilum (4); and longitudinal hilar vessels (5). (a–c) Normal lymph node with nodal-core sign present and complete, i.e. visible hyperechogenic medulla and hilum. (d–f) Lymph node with partial nodal-core sign. Due to reactive process, cortical thickening compresses hilum, so it cannot be seen, but medulla is still clearly visible. (g–i) Metastatic lymph node with absent nodal-core sign; neither hyperechogenic hilum nor medulla can be recognized. Transcapsular neovascular vessels (6) run along nodal periphery, with branches perforating into lymph node, which has been replaced completely by metastatic tumor cells. See also Videoclip S5.

Grouping is absent when lymph nodes can be recognized as separate entities, with a minimum of residual perinodal tissue separating them. In partial grouping, lymph nodes are joined in clusters or lined up, but the individual nodal borders are still identifiable. In complete grouping, lymph nodes appear as an ill-defined structure with no preserved lymph-node borders, due to enlargement of the lymph nodes and extracapsular extension of tumor growth<sup>21</sup>.

It is impossible to describe the grouping of lymph nodes in static images or clips presenting lymph nodes without sufficient perinodal tissue.

### Color and power Doppler assessment

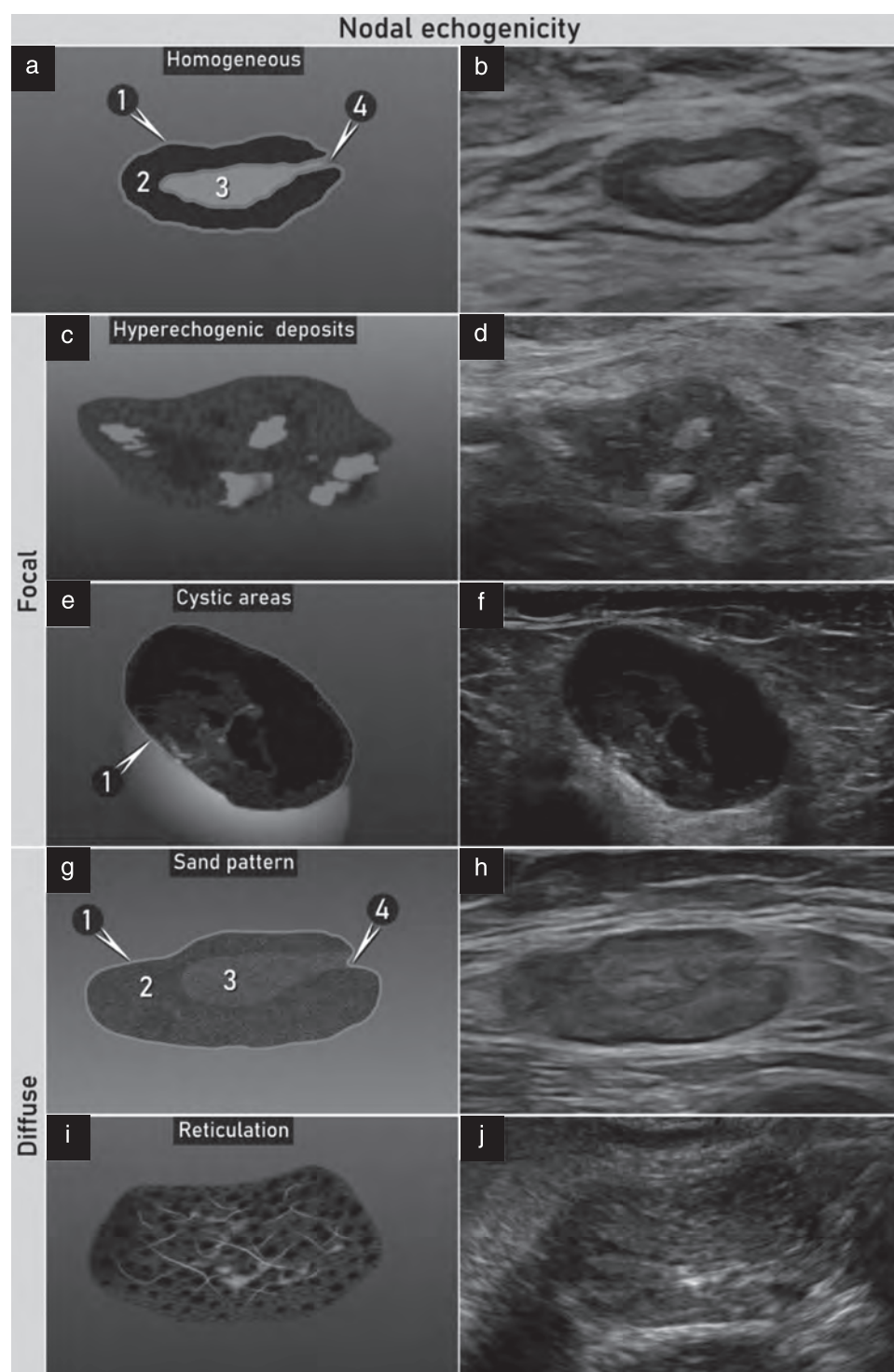
Assessment of lymph-node vascularization comprises both description of the architecture of the blood vessels and subjective quantification of the amount of blood flow.



**Figure 9** Schematic diagrams and ultrasound images showing different types of cortical thickening. Indicated are: capsule (1); cortex (2); medulla (3); hilum (4); and longitudinal hilar vessels (5). (a–c) Normal lymph node (LN), without cortical thickening. Medulla is thicker than cortex, measured parallel to short axis of LN (for measurement technique, see Figure 6). (d–f) Focal cortical thickening (focal bulging), i.e. thickening of < 50% of nodal circumference (nodal circ), in LN with intranodal focal metastatic lesion. (g–i) Concentric uniform cortical thickening (≥ 50% of nodal circ) in reactive LN. Nodal core is in central position. Cortical thickening is uniform on both sides. (j–l) Concentric non-uniform cortical thickening (≥ 50% of nodal circ) in reactive LN. Nodal core is in central position. Non-uniform cortical thickening has thinner and wider segments. (m–o) Eccentric uniform cortical thickening (≥ 50% of nodal circ) in LN with metastasis. Nodal core with residual lymphatic tissue is displaced laterally. (p–r) Eccentric non-uniform cortical thickening (≥ 50% of nodal circ) in LN with metastasis. Nodal core is displaced to periphery. See also Videoclip S6.

Color and power Doppler are used to assess abnormal lymph nodes. When color or power Doppler ultrasound is used to visualize the vascular architecture of a lymph node, low pulse repetition frequency (pulse repetition frequency, 0.3–0.6 KHz) and low wall filter (wall filter,

50–100 Hz) must be used to enable detection of as many blood vessels as possible. The gain is increased to the point of significant color noise and is then slowly reduced until all artifacts disappear. The Doppler frequency must correspond to the required penetration depth. Pressure



**Figure 10** Schematic diagrams and ultrasound images showing different types of nodal echogenicity. Indicated are: capsule (1); cortex (2); medulla (3); and hilum (4). (a,b) Homogeneous echogenicity of cortex of normal lymph node. (c,d) Non-homogeneous focal echogenicity with scattered hyperechogenic deposits, in metastatic lymph node (low-grade ovarian serous cancer). (e,f) Non-homogeneous focal cystic areas in metastatic lymph node (vulvar cancer). (g,h) Non-homogeneous diffuse sand pattern with multiple tiny hyperechogenic spots dispersed throughout cortex, in lymph node with postreactive changes and lymphatic stasis due to ascites. (i,j) Non-homogeneous diffuse reticulation characterized by thin echogenic lines separating hypoechogenic tissue, producing microcystic-like pattern, in lymph node with lymphoma. See also Videoclip S7.

should be minimized, or ideally avoided completely, during Doppler examination, because blood flow may be reduced or blocked by pressure<sup>2,21</sup>.

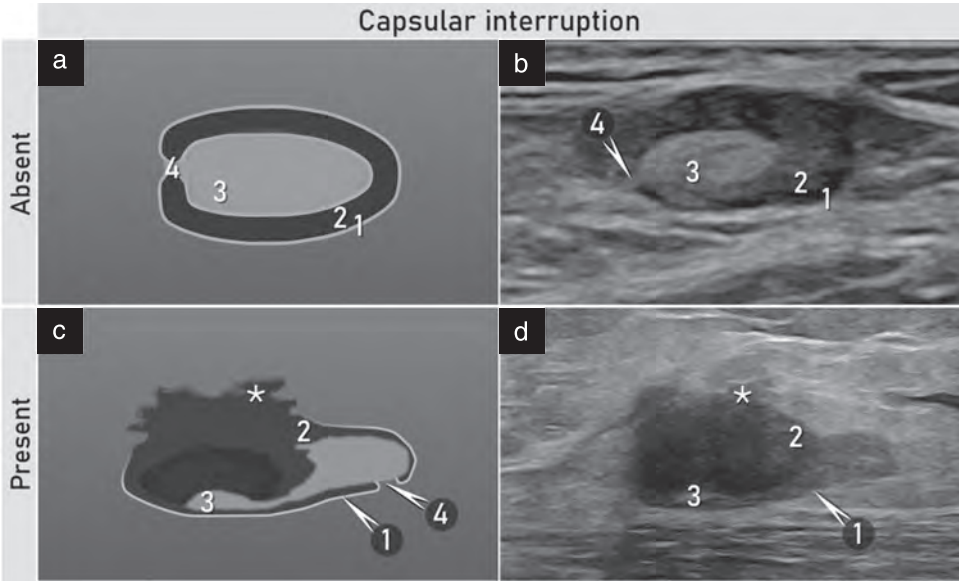
*Blood-vessel architecture*

The architecture of blood vessels can be assessed only when the vessel can be visualized in its entirety. This is usually the case for color scores 3 and 4 (see Color score, below). Vessel architecture should be reported as hilar flow (central flow along the longitudinal hilar vessels, parallel to the nodal long axis, with radial vessels

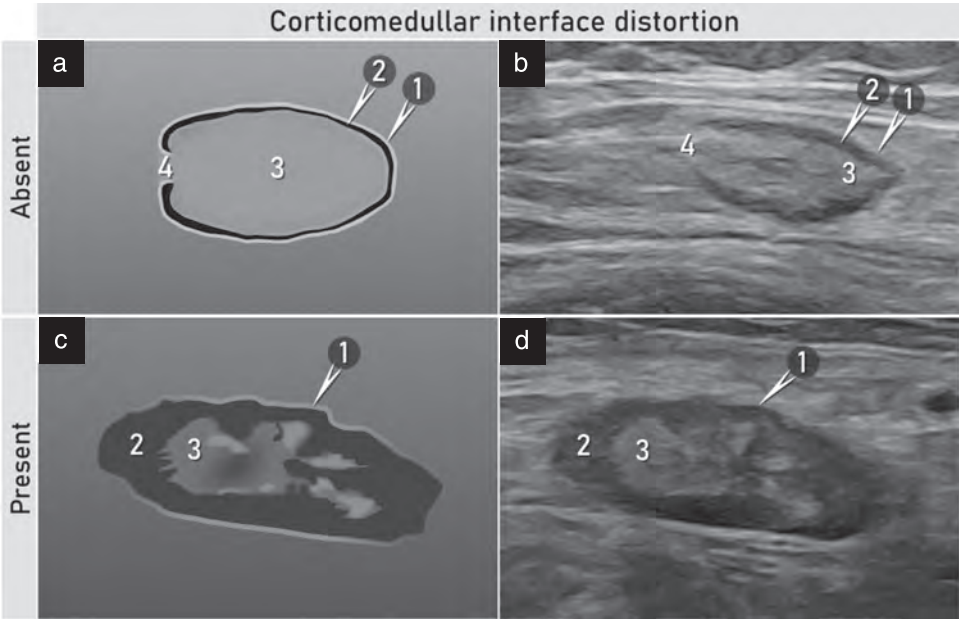
branching perpendicular to central flow), transcapsular flow (vessels penetrating the cortex from outside) or, when both hilar and transcapsular flow is present, combined flow (Figure 15, Videoclip S12).

*Color score*

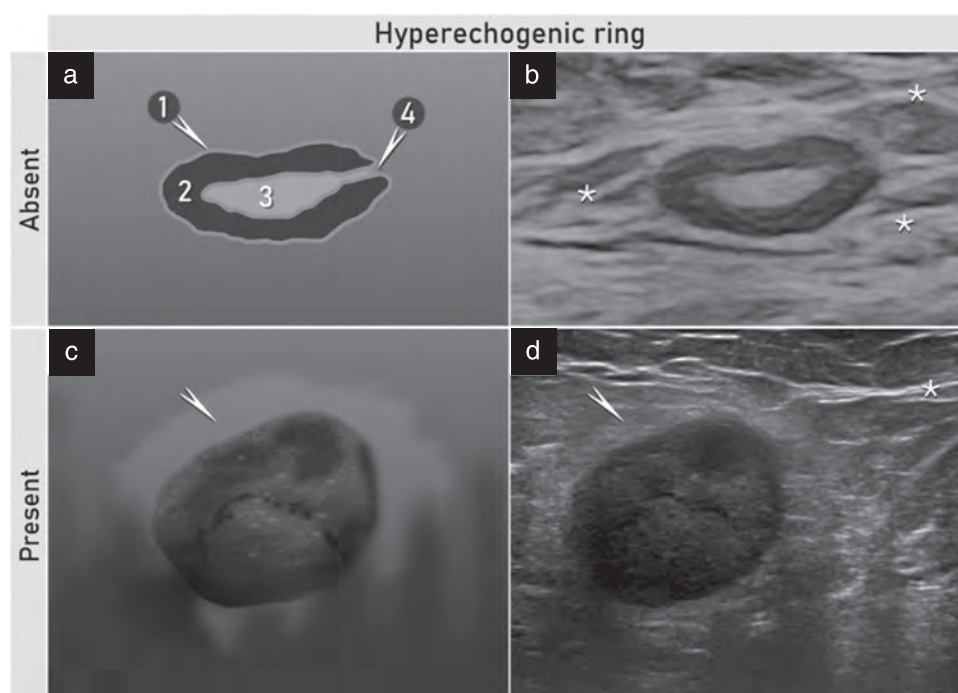
Once the architecture of blood vessels has been assessed, the amount of blood flow should be quantified. The color score is a subjective, semiquantitative evaluation of the color content of a lymph node, using color or power Doppler ultrasound examination. It represents the



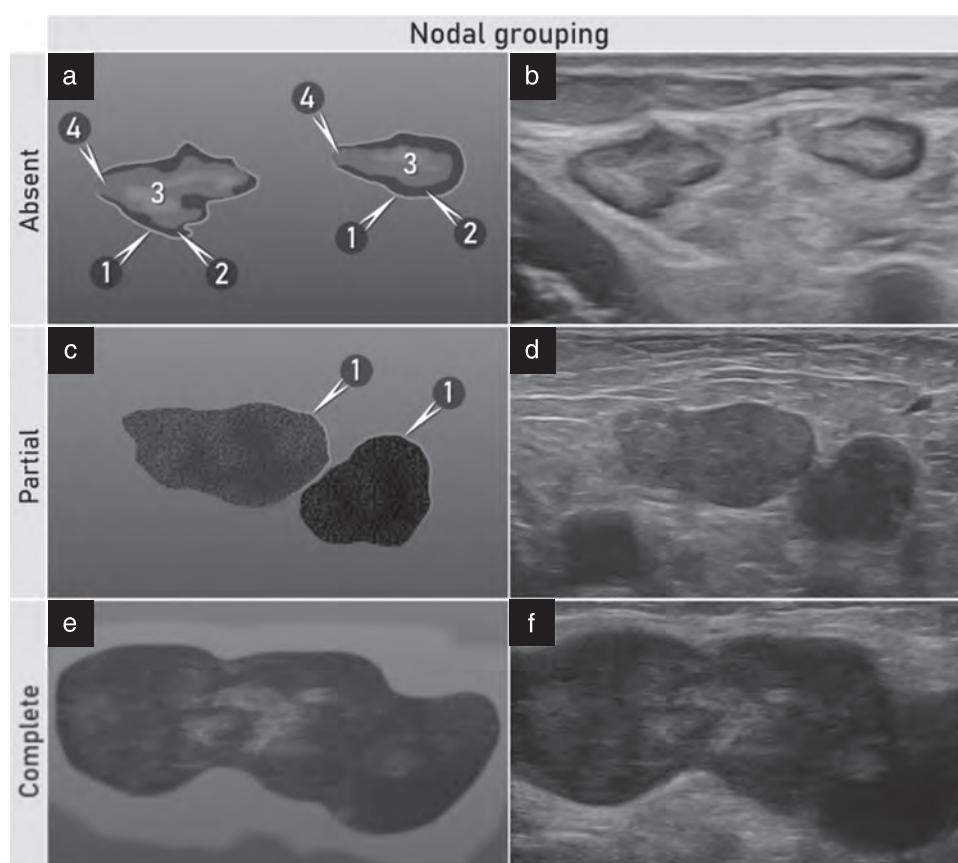
**Figure 11** Schematic diagrams and ultrasound images showing capsular interruption. Indicated are: capsule (1); cortex (2); medulla (3); and hilum (4). (a,b) Normal lymph node with continuous, smooth capsule and absent capsular interruption. (c,d) Metastatic lymph node with capsular interruption (\*) and blurred nodal border due to tumor projections into perinodal fat tissue. See also Videoclip S8.



**Figure 12** Schematic diagrams and ultrasound images showing distortion of corticomedullar interface. Indicated are: capsule (1); cortex (2); medulla (3); and hilum (4). (a,b) Postreactive lymph node with absent distortion of corticomedullar interface, i.e. smooth border between medulla and cortex. (c,d) Reactive lymph node with distorted interface, without smooth border, between medulla and cortex. See also Videoclip S9.



**Figure 13** Schematic diagrams and ultrasound images showing hyperechogenic-ring sign. Indicated are: capsule (1); cortex (2); medulla (3); and hilum (4). (a,b) Normal lymph node. In perinodal fat tissue, sharply demarcated hyperechogenic septa are seen between tissue with homogeneous texture (\*). (c,d) Completely infiltrated metastatic lymph node (vulvar cancer) with blurred hyperechogenic halo around node, i.e. hyperechogenic ring (arrow). More distantly, perinodal tissue has normal appearance (\*). See also Videoclip S10.



**Figure 14** Schematic diagrams and ultrasound images demonstrating nodal grouping. Indicated are: capsule (1); cortex (2); medulla (3); and hilum (4). (a,b) Absent grouping. Separate normal lymph nodes are seen clearly. (c,d) Partial grouping of lymph nodes with metastasis from vulvar cancer. Two lymph nodes are in contact, but it is still possible to recognize individual nodes and their borders. (e,f) Complete grouping of lymph nodes infiltrated by vulvar cancer. It is not possible to distinguish one lymph node from another; they are matted together as single undefined mass. See also Videoclip S11.

amount of blood flow in the vascular tree of a lymph node. Scoring is similar to the color score suggested by the International Ovarian Tumor Analysis (IOTA) group for use in adnexal masses: a color score of 1 is no color, a score of 2 is minimal color (minimal scattered color signals), a score of 3 is moderate color (the entire length of the vessel/vessels can be observed) and a score of 4 is abundant color (Figure 16, Videoclip S13)<sup>26</sup>. The clinical significance of the color score in inguinal lymph nodes has yet to be determined, but it should be described in the ultrasound report.

## GENERAL ULTRASOUND CHARACTERISTICS OF INFILTRATED AND NON-INFILTRATED LYMPH NODES

Having identified the deep and superficial lymph nodes and their exact location, and having described them using VITA nomenclature, the lymph-node status is defined using pattern recognition, i.e. subjective assessment of the ultrasound appearance of the lymph node. Lymph nodes are described as normal, reactive, postreactive or infiltrated (metastatic), on the basis of their grayscale

ultrasound morphology and their vascular pattern on color or power Doppler ultrasound.

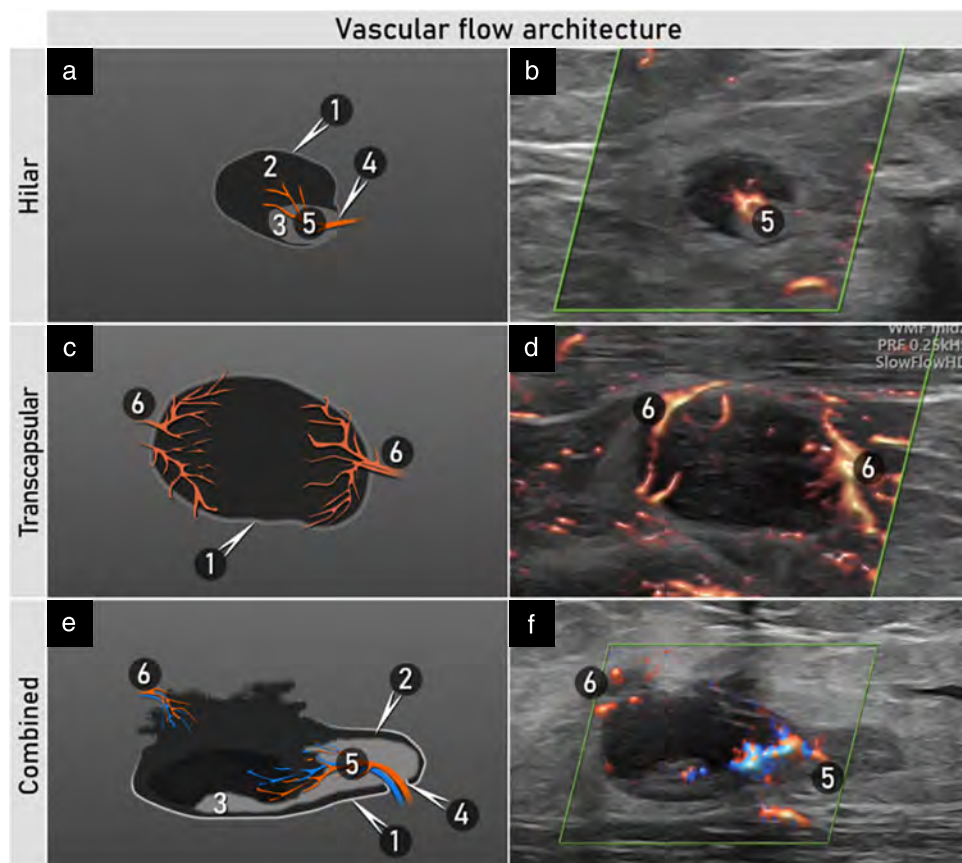
### Non-metastatic (non-infiltrated) lymph nodes

#### Normal lymph node

Normal lymph nodes are small, oval-shaped formations (Figure 17, Videoclip S14). On ultrasound, the inner central hyperechogenic medulla is surrounded by a homogeneous hypoechoic cortex and thin continuous hyperechogenic capsule. The hyperechogenic nodal hilum interrupts the continuity of the cortical border and is continuous with the adjacent perinodal soft (fatty) tissue. The blood vessels that pass through the hilum into the medulla (the longitudinal hilar vessels) branch in the lymph-node periphery and are detectable with color and power Doppler ultrasound<sup>27–33</sup>.

#### Reactive lymph node

Reactive lymph nodes tend to be oval in shape, with nodal-core sign present, consisting of the hyperechogenic medulla and hilum, with uniform concentric cortical



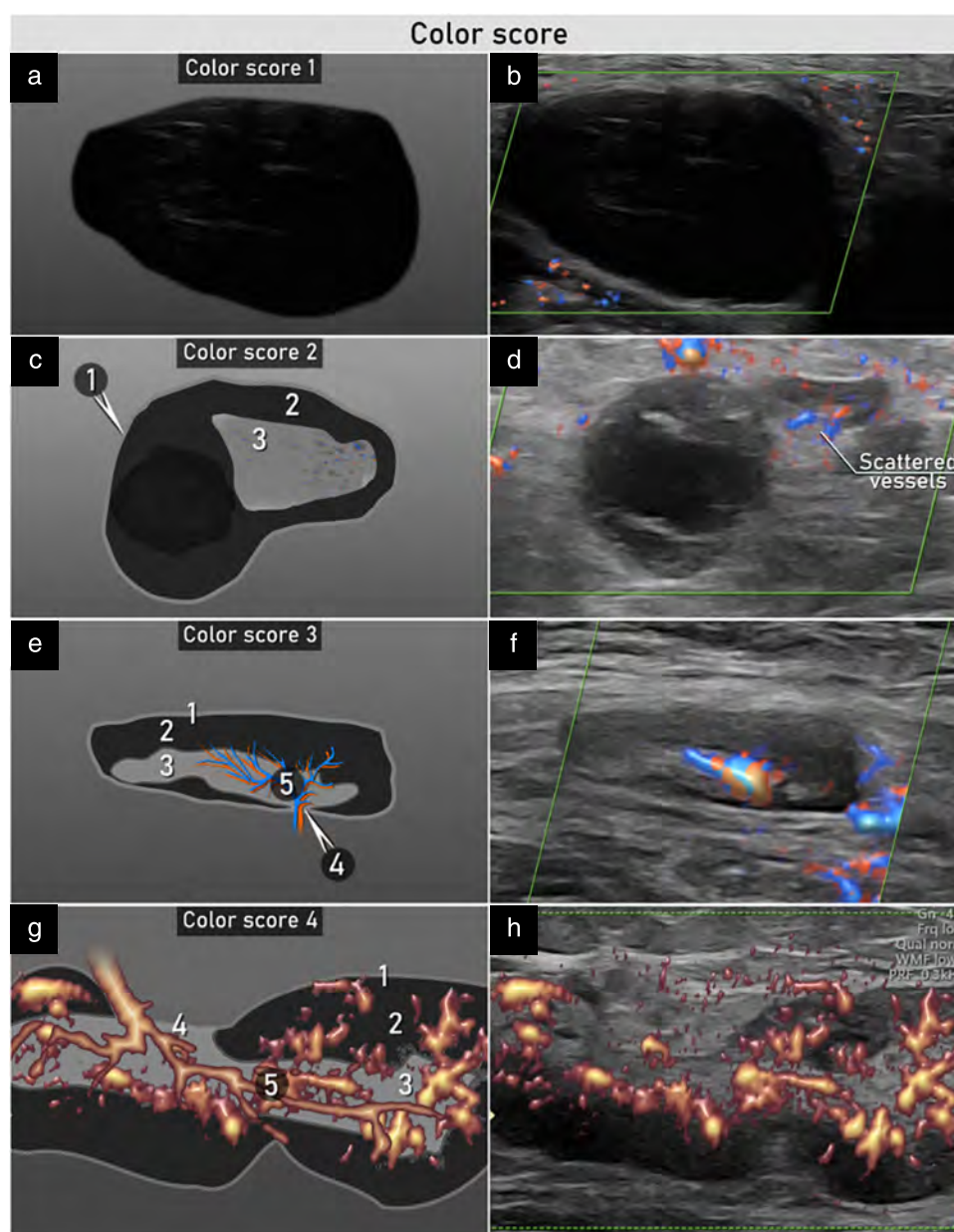
**Figure 15** Schematic diagrams and ultrasound images showing different types of vascular flow architecture. Indicated are: capsule (1); cortex (2); medulla (3); hilum (4); longitudinal hilar vessels (5); and transcapsular flow (6). (a,b) Hilar flow. Vessels enter lymph node at hilum (longitudinal hilar vessels (5)) and branch in medulla towards periphery of node. (c,d) Transcapsular flow, i.e. circumferential vascularization with perforating vessels invading cortex from outside. This is explained by neovascularization. (e,f) Combined flow. Lymph node manifests both hilar (5) and transcapsular (6) vascular flow architecture. See also Videoclip S12.

thickening of the hypoechoic cortex due to the activation of the immune response (Figure 18, Videoclip S15). Concentric cortical thickening is defined as diffuse thickening of the cortex surrounding the medulla, which is located centrally. Usually, this widening occurs uniformly, so that the oval shape is preserved<sup>21,22</sup>. On color/power Doppler ultrasound, reactive lymph nodes show an intensified normal vascular tree that branches from the central hilar region (branching of longitudinal hilar vessels)<sup>21</sup>. Rarely, reactive lymph nodes may have neither visible hyperechoic hilum nor hyperechoic medulla and they may have a round shape while maintaining enhanced hilar flow (Figure 18). In the case of lymphomas, the infiltrated lymph nodes may be indistinguishable from

reactive lymph nodes on ultrasound, even with the application of color or power Doppler sonography, showing regular branching of arteries.

### Postreactive lymph node

Postreactive lymph nodes are benign nodes, characterized on ultrasound by the presence of the so-called fat-hilum sign, i.e. a wide hilum, with hilar flow, enlarged central hyperechoic medulla and thin cortex<sup>34</sup>. Moreover, the cortex often becomes thinner, and the medulla wider, with age. If there is scarring and atrophy of the lymph node, the cortex becomes bulged (uneven) and nearly isoechoic to the surrounding fat<sup>35</sup>. As a consequence



**Figure 16** Schematic diagrams and ultrasound images demonstrating color score. Indicated are: capsule (1); cortex (2); medulla (3); hilum (4); and longitudinal hilar vessels (5). (a,b) Color score 1, i.e. no visible blood flow, in lymph node with metastasis from vulvar cancer. (c,d) Color score 2, i.e. minimal blood flow, with scattered vessels in residual normal lymph node and no flow in intranodal metastasis. (e,f) Color score 3, i.e. moderate blood flow, in reactive (non-metastatic) lymph node. (g,h) Color score 4, i.e. abundant flow, in reactive (non-metastatic) lymph node in patient with leg ulcer. See also Videoclip S13.

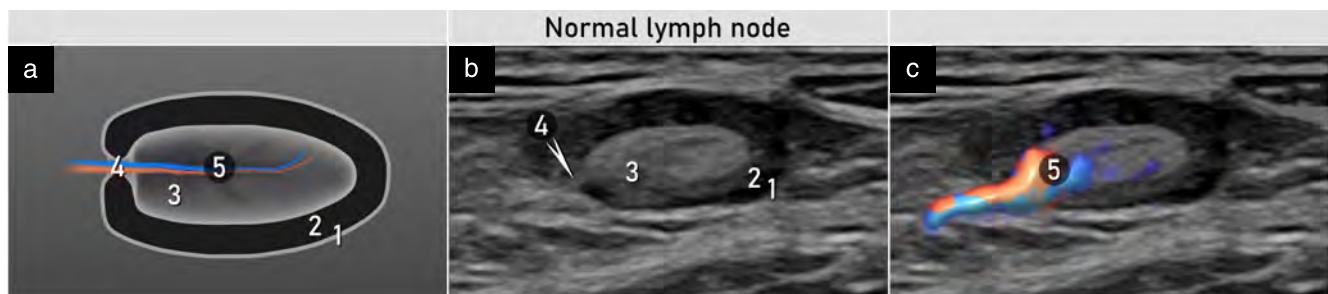
of lipomatous replacement of the medullary sinuses during the healing process after inflammation, three zones can be observed. A moderately hypoechogenic zone that corresponds to pure fat tissue is seen centrally. This hypoechogenic center is always separated from the hypoechogenic cortex by a hyperechogenic line (fibrovascular tissue), resulting in a sandwich-like appearance (Figure 19, Videoclip S16). This appearance is not always a consequence of fatty involution; it can be a normal variant of a lymph node. If this normal variant is present, it is detected bilaterally in the groins and axillae, but never in the head and neck regions.

### Metastatic (infiltrated) lymph nodes

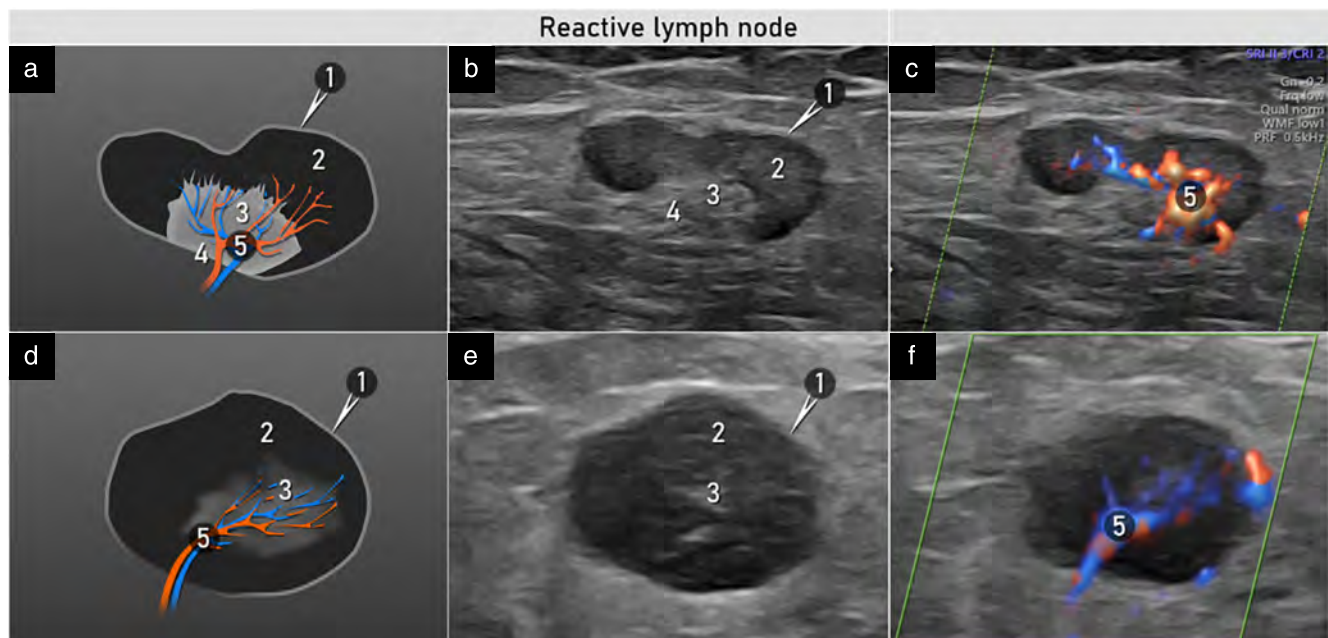
The invasion of lymph nodes by metastatic tumor cells usually changes the sonographic architecture of the lymph node. Micrometastases (0.2–2 mm in diameter),

or small-volume metastases, with diameter < 3 mm, may not cause changes in lymph-node morphology and so cannot be visualized with imaging methods<sup>21,36</sup>. Changed shape and cortical thickening of a lymph node may be the first sign of tumor infiltration<sup>37</sup>.

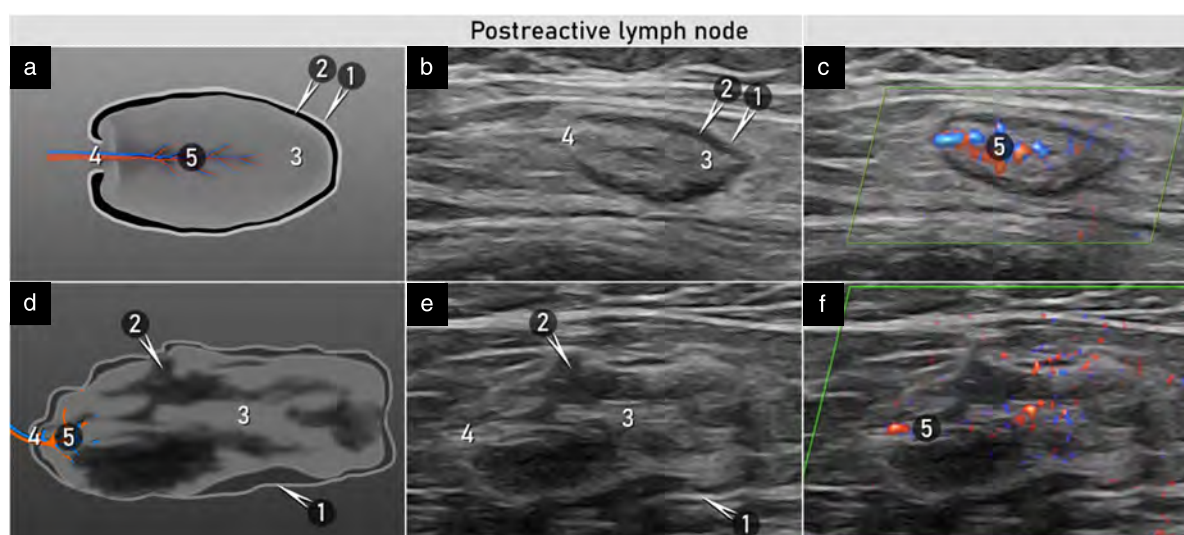
Partial infiltration of lymph nodes by cancer cells or melanoma typically manifests eccentric cortical thickening, which is defined as uniform or non-uniform cortical thickening that displaces the residual hyperechogenic hilum and medulla to the periphery of the lymph node. Cortical echogenicity is non-homogeneous or markedly hypoechogenic compared with the adjacent soft tissue. The non-homogeneous cortical echogenicity is explained mainly by focal changes, which usually correspond to cystic areas due to colliquative necrosis<sup>21</sup>. Capsular interruption and transcapsular vascular flow architecture may also be found (Figure 20, Videoclip S17).



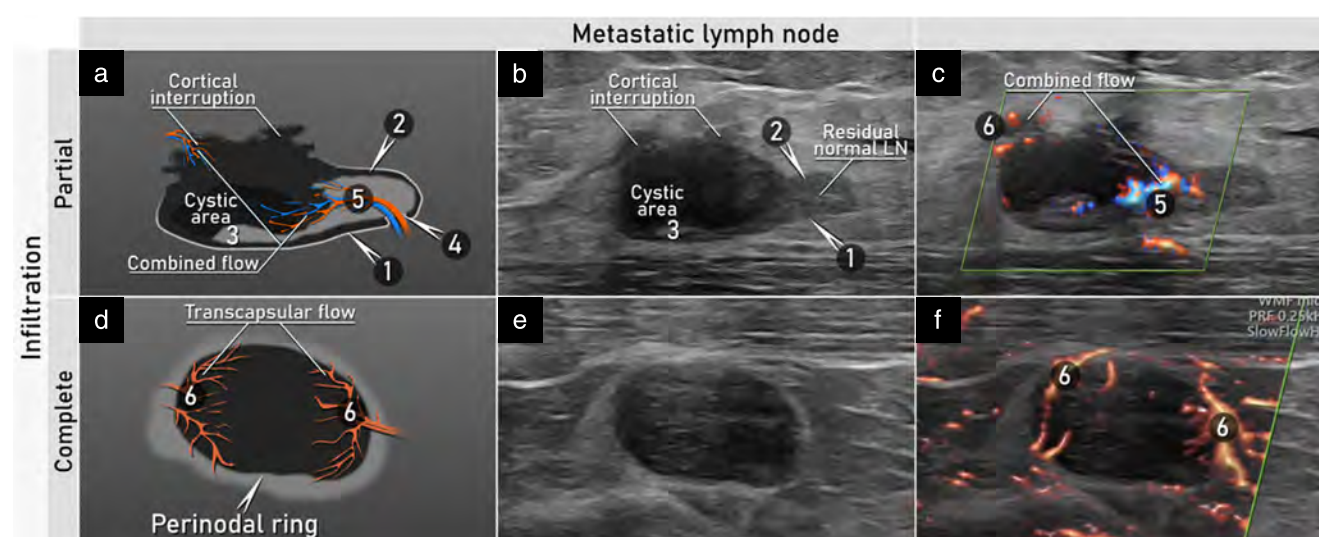
**Figure 17** Schematic diagram (a), grayscale ultrasound image (b) and color Doppler image (c) of normal lymph node. Indicated are: capsule (1); cortex (2); medulla (3); hilum (4); and longitudinal hilar vessels (5). Normal lymph node has oval shape and central hyperechogenic medulla surrounded by homogeneous hypoechogenic cortex, and manifests hilar flow. See also Videoclip S14.



**Figure 18** Schematic diagrams, grayscale ultrasound images and color Doppler images of reactive lymph nodes. Indicated are: capsule (1); cortex (2); medulla (3); hilum (4); and longitudinal hilar vessels (5). (a–c) Reactive lymph node with cortical concentric thickening, and abundant hilar flow with branching towards cortex in reaction to lymphatic drainage of antigens. (d–f) Reactive lymph node in which cortical thickening is particularly pronounced, giving round shape to lymph node. Homogeneous cortical echogenicity hides hilum completely and medulla almost completely; longitudinal hilar vessels (5) are still visible on color Doppler. See also Videoclip S15.



**Figure 19** Schematic diagrams, grayscale ultrasound images and color Doppler images of postreactive lymph nodes. Indicated are: capsule (1); cortex (2); medulla (3); hilum (4); and longitudinal hilar vessels (5). (a–c) Postreactive lymph node with preserved hilar flow and hyperechogenic wide medulla, contrasting with thin surrounding cortex. (d–f) Postreactive lymph node showing lipomatous replacement of hilum, which has become isoechogetic to hypoechogenic perinodal fat tissue. Large hypoechogenic hilum is separated from thin and uneven cortex by thinner hyperechogenic stripe (fibrovascular tissue). See also Videoclip S16.

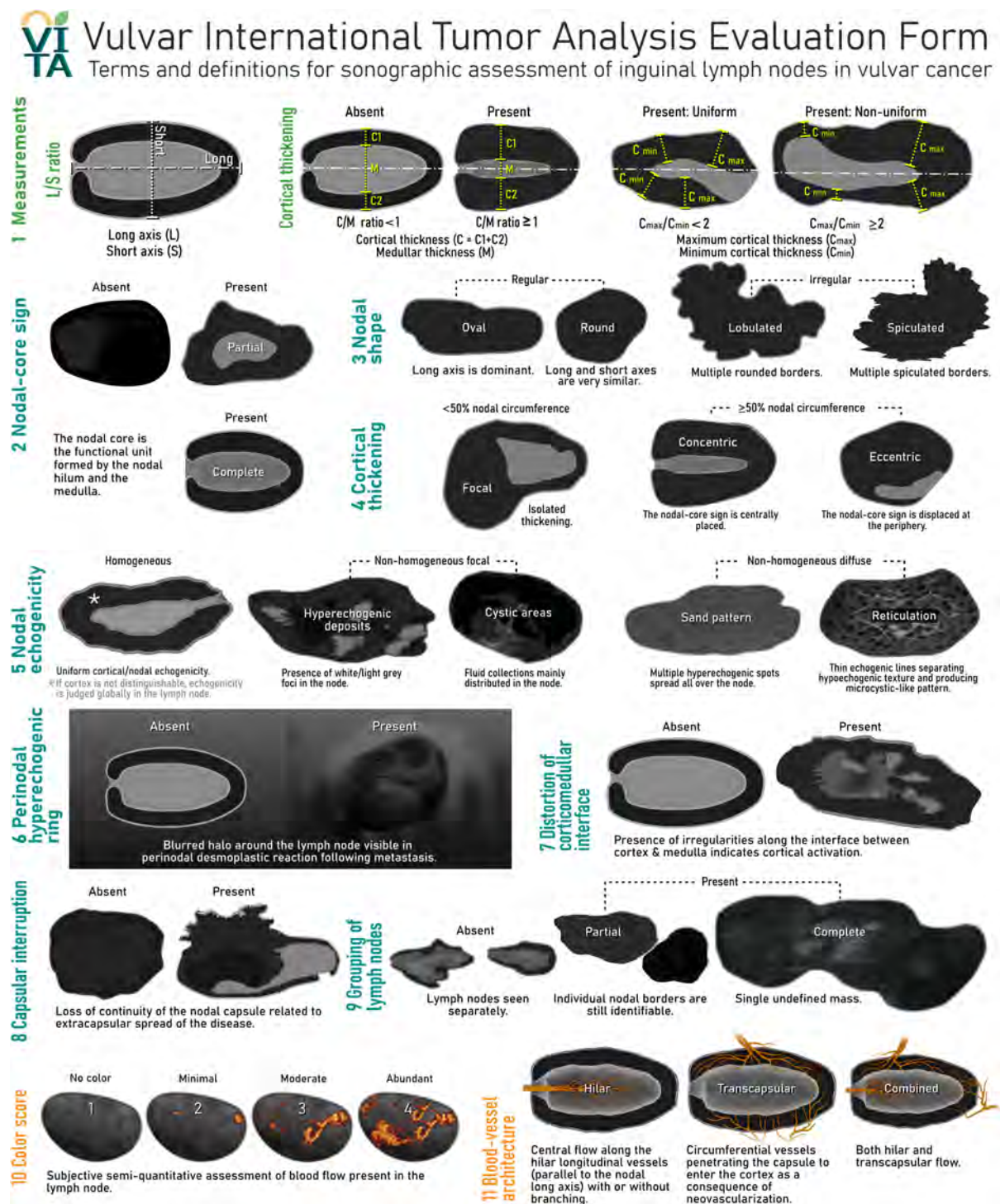


**Figure 20** Schematic diagrams, grayscale ultrasound images and color Doppler images of metastatic lymph nodes (LN). Indicated are: capsule (1); cortex (2); residual medulla (3); hilum (4); longitudinal hilar vessels with characteristic hilar flow (5); and transcapsular flow with penetrating vessels (6). (a–c) LN with partial metastatic infiltration, characterized by large intranodal metastasis, and small residuum of normal LN with visible medulla and hilar vascular flow, combined with transcapsular flow penetrating intranodal metastasis. Intranodal metastasis shows capsular interruption and cystic (anechogenic) areas. (d–f) LN with complete metastatic infiltration. It has round shape and non-homogeneous diffuse cortical echogenicity with sand pattern. Nodal-core sign is absent. Only vessels penetrating node from outside with transcapsular flow pattern are visible (moderate color score). Hyperechogenic perinodal ring is also present. See also Videoclip S17.

Lymph nodes infiltrated completely by cancer cells or melanoma tend to be round, with loss of hyperechogenic hilum and medulla, because the lymph node has been replaced by tumor cells (Figure 20, Videoclip S17)<sup>9,21,36</sup>. If a high-resolution linear-array probe is used in a targeted search for displaced hilum and medulla, intranodal metastasis (partial lymph-node infiltration) with displacement of residual lymph-node tissue towards the periphery is seen more often than is complete diffuse lymph-node infiltration.

## DISCUSSION

This paper is the consensus opinion of a group of gynecologists and radiologists dedicated to ultrasonography and gynecologic oncology. The aim is to present a standardized examination technique, measurement technique and terminology that should be used to describe the ultrasound appearance of lymph nodes in the groin in patients with vulvar cancer, and that can be used for staging purposes. The terminology is summarized in Figure 21. There is no



**Figure 21** Schematic diagrams showing measurements and terminology to be used to describe lymph nodes according to VITA (Vulvar International Tumor Analysis) consensus opinion (Appendix S2).

international consensus on the ultrasound assessment of lymph nodes in any condition. The lack of standardized nomenclature to describe the ultrasound appearance of lymph nodes makes it difficult to compare results from different ultrasound studies. Various non-standardized terms are used in the literature to describe cervical lymph nodes in patients with tumors in the head or neck<sup>20,38</sup>, and axillary lymph nodes in breast-cancer patients<sup>39</sup>. Due to the lack of standardized sonographic terms, it is difficult to describe the characteristics of lymph

nodes infiltrated by cancer or lymphoma, and impossible to compare ultrasound patterns between lymph-node metastases from different primary cancers. Complicating matters further, the ultrasound appearance of normal peripheral lymph nodes differs between head and neck, axillary and inguinal lymph nodes. These differences should also be described using standardized terms.

The IOTA group, the International Endometrial Tumor Analysis (IETA) group and the Morphological Uterus Sonographic Assessment (MUSA) group have agreed on

which terminology one should use to describe adnexal, endometrial and myometrial lesions, respectively<sup>26,40,41</sup>. The use of standardized terms and definitions has been of the utmost importance for development and validation of methods for predicting malignancy in ovarian or uterine tumors, and for assessing the risk of metastatic lymph nodes in endometrial cancer<sup>26,40,42–45</sup>. By analogy, the VITA examination technique, measurement technique and terminology should serve as a basis for prospective studies to assess the agreement between sonographic features of lymph nodes and histopathological diagnosis.

The VITA document is not definitive and will be adjusted based on the results of future studies. We are aware that lymph-node description in clinical practice may be less detailed than as discussed herein. However, we believe that the systematic standardized approach that we present should guarantee detailed assessment of inguinal lymph nodes and precise reporting of ultrasound findings, and that it will facilitate implementation of ultrasound as the primary tool for staging of vulvar cancer; suggestions for standardized reporting are given in Appendix S5. Ultrasound is the first-choice imaging modality for evaluation of peripheral lymph-node status in patients with inflammatory or malignant disease. The nomenclature proposed herein may be applied not only for assessment of inguinal lymph nodes with the purpose of vulvar cancer staging, but also for ultrasound assessment of peripheral lymph nodes in general. Furthermore, it may be applied to the assessment of non-peripheral (parietal or visceral) lymph nodes, if these can be visualized clearly. Our upcoming multicenter interobserver study will provide more data on the generalizability of the proposed VITA terms, potentially supporting their wider use in the future.

## ACKNOWLEDGMENTS

We thank Adam Preisler (Polygoniq Studio) for providing the illustrations and Tomas Herrmann (Institute of Scientific Information, First Faculty of Medicine, Charles University Prague, Czech Republic) for video editing. This work was supported by Charles University in Prague (UNCE 204065 and PROGRES Q28/LF1), by a project of the Ministry of Health of the Czech Republic (grant nr. NV19-03-00552), by Freie Akademische Gesellschaft Basel (FAG – Switzerland) and by the G. & J. Bangerter-Rhyner-Foundation (Switzerland).

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## SUPPORTING INFORMATION ON THE INTERNET

The following supporting information may be found in the online version of this article:

-  **Appendix S1** Original studies presenting data on accuracy of imaging in assessment of infiltrated inguinal lymph nodes in vulvar cancer
- Appendix S2** Supplementary VITA consensus statement (includes Figures S1–S11, Videoclips S1 and S2)
- Appendix S3** Three useful steps and landmarks to assess femoral triangle when scanning (Videoclip S18)
- Appendix S4** Tips and tricks when scanning groin for localization of inguinal lymph nodes (Videoclip S19)
- Appendix S5** Standardized ultrasound report of inguinal lymph-node assessment
-  **Videoclip S1** Left femoral triangle: boundaries and content (anatomical dissection).
- Videoclip S2** Inguinal superficial and deep lymph nodes in left groin (anatomical dissection).
- Videoclip S3** How to scan groin in vulvar cancer.
- Videoclip S4** Lymph-node shape.
- Videoclip S5** Nodal-core sign.
- Videoclip S6** Cortical thickening.
- Videoclip S7** Nodal echogenicity.
- Videoclip S8** Capsular interruption.
- Videoclip S9** Corticomedullar interface distortion.
- Videoclip S10** Hyperechogenic ring.
- Videoclip S11** Nodal grouping.
- Videoclip S12** Vascular flow architecture.
- Videoclip S13** Color score.
- Videoclip S14** Normal lymph node.
- Videoclip S15** Reactive lymph nodes.
- Videoclip S16** Postreactive lymph node.
- Videoclip S17** Metastatic inguinal lymph nodes.
- Videoclip S18** Three useful tips and tricks for assessing femoral triangle using ultrasound (right groin).
- Videoclip S19** How to differentiate deep from superficial inguinal lymph nodes in left groin using ultrasound.



A video presentation  
summarizing the content  
of this article is available online



## Términos, definiciones y medidas para describir las características ecográficas de los ganglios linfáticos: opinión consensuada del grupo *Vulvar International Tumor Analysis* (VITA)

### RESUMEN

En los centros con acceso a tecnología ecográfica de alta gama y especialistas en ecografía, esta técnica se utiliza para detectar la metástasis en los ganglios linfáticos regionales del melanoma, el cáncer de mama y el cáncer de vulva. Todavía no existe un consenso internacional sobre la evaluación ecográfica de los ganglios linfáticos en ninguna enfermedad o condición médica. La falta de una nomenclatura ecográfica estandarizada para describir los ganglios linfáticos dificulta la comparación de los resultados de diferentes estudios ecográficos y la búsqueda de características ecográficas fiables para distinguir los ganglios linfáticos no infiltrados de los ganglios linfáticos infiltrados por células cancerosas o de linfoma maligno. El grupo de colaboración del *Vulvar International Tumor Analysis* (VITA) está formado por especialistas en ginecología, ginecología oncológica y radiología con experiencia en cáncer ginecológico, especialmente en la estadificación ecográfica y el tratamiento del cáncer de vulva. El presente trabajo es una opinión consensuada sobre los términos, las definiciones y las medidas que pueden utilizarse para describir los ganglios linfáticos inguinales en la ecografía Doppler, tanto en escala de grises como en color o *power-Doppler*. La nomenclatura propuesta no tiene por qué limitarse a la descripción de los ganglios linfáticos inguinales como parte de la estadificación del cáncer de vulva, sino que puede utilizarse también para describir los ganglios linfáticos periféricos en general, así como los ganglios linfáticos no periféricos (es decir, los parietales o los viscerales) si éstos pueden observarse claramente. Todavía no se ha establecido la asociación entre las características ecográficas aquí descritas y el diagnóstico histopatológico. Los términos y las definiciones del grupo VITA sientan las bases para los estudios prospectivos destinados a identificar las características ecográficas típicas de las metástasis y de otras patologías en los ganglios linfáticos, así como para los estudios destinados a dilucidar el papel de la ecografía en la estadificación de las neoplasias vulvares malignas y otras.

描述淋巴结超声表现特征的术语、定义及评价方法：来自外阴国际肿瘤分析组（VITA）的共识

### 摘要

在拥有高端超声仪器和专业超声医生的医疗中心，采用超声波来探测黑色素瘤、乳腺癌和外阴癌局部淋巴结内的转移。迄今为止，对任何疾病的淋巴结超声检测尚未达成国际共识。没有描述淋巴结的标准化超声命名法，使我们难以比较不同超声研究的结果，也难以找到区别非浸润性淋巴结和癌症或淋巴瘤细胞浸润淋巴结的可靠的超声表现特征。外阴国际肿瘤分析（VITA）合作组由妇科癌症专业（尤其是外阴癌的超声分期及治疗方面）的妇科医生、妇科肿瘤医生和放射科医生组成。本文表述了在灰度图和彩色/能量多普勒超声中可用于描述腹股沟淋巴结的术语、定义及评价方法的共识。此提议命名法不必局限于外阴癌分期中对腹股沟淋巴结的描述。它一般可用于描述外周淋巴结和非外周（如腔壁或内脏）淋巴结（若清晰可见）。在此描述的超声表现特征与组织病理学诊断之间的关联尚未得到建立。VITA 术语和定义为以识别转移癌特有的超声表现特征和淋巴结中的其他病理学为目的的前瞻性研究奠定基础，也为说明超声在外阴及其他恶性肿瘤分期中所起作用的研究奠定基础。