Clinical Imaging 38 (2014) 96–99

Contents lists available at ScienceDirect

Clinical Imaging

journal homepage: http://www.clinicalimaging.org

Analysis by high resolution ultrasound of superficial lymph nodes: anatomical, morphological and structural variations

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ARTICLE INFO

Article history:
Received 5 March 2013
Received in revised form 20 August 2013
Accepted 21 November 2013

Keywords:
Ultrasound
Lymph node
Variations
Metastases
Cortical thickening
Hilum

ABSTRACT

Purpose: To analyze morphostructural variations of benign lymph nodes, 49 cervical , 49 axillary and 49 inguinal lymph nodes had been studied in many healthy subjects.
Methods: Longitudinal and transverse diameters, longitudinal to transverse axis ratio, hilum and cortex thickness, hilar to cortical thickness ratio, presence and echogenicity of hilum, and presence of cortical focal thickening had been evaluated.
Results: Some parameters were statistically significant such as for the presence of hilum that was identified in 100% of axillary and inguinal lymph nodes.
Conclusions: Morphostructural differences must be considered in order to avoid the possible misinterpretation between the physiologic and pathologic LN.

1. Introduction

Ultrasound is commonly used for the evaluation of superficial lymph nodes (neck, armpit, and groin), and its role is well documented [1–4]. The absence of an echogenic hilum, the round shape (ratio of longitudinal to transverse diameter <2), and the presence of abnormal capsular vascularization, highlighted by the Doppler test, are described in literature as characteristic signs of lymph node metastasis [5–10]. These signs are useful for the identification of metastases involving lymph nodes at the global level; however, the technological progress of high-frequency transducers and the increasing need for early detection of lymph node metastasis have led us to give more importance to small nodes and minor alterations. Among these minor signs, focal thickening or cortical bulge, diffuse cortical thickening and the presence of focal areas of altered echogenicity should be stated [11–14]. These minor changes may be indicative of early stage lymph nodes metastasis, but to a certain degree, they overlap with morphostructural variations that could be found also in normal lymph nodes. Indeed normal lymph nodes are described as oval formations with regular contours and central echogenic hilum surrounded by thin and homogeneous hypoechoic cortex [4]. However, in addition to these typical aspects, anatomical variations are frequently detected and may lead to a misinterpretations if assessed as an early sign of metastasis. The purpose of this study is to analyze the characteristics of normal lymph nodes in different sites: the frequency of all anatomical variations was evaluated, and these were compared to the sonographic features of benign lymph nodes to obtain useful information for the proper recognition of apparent anomalies that do not represent a reliable sign of disease.

2. Materials and methods

From March until September 2012, a consecutive series of 147 patients (F:M = 83:64; median age 51.9 years, age range 18–92 years) was investigated for common non-neoplastic diseases (e.g., gallstones, prostatic hypertrophy).

The study was approved by the ethics committee of our hospital. All patients included in the study were informed about it and they signed an informed consent form. Sonography was performed on lymph nodes randomly chosen from one of the preselected groups (lateral cervical, axillary and inguinal). Up to 49 lymph nodes had been investigated in each one of the three anatomical sites.

All morphostructural evaluations and measurements were performed on one lymph node of each anatomical region. If the lymph nodes of one region differed one from the others, the one showing more variations from the classic pattern had been selected.

All ultrasound scans were performed by a radiologist with over 20 years of experience. The same equipment (Logos HiVision E, Hitachi, Medical Systems Europe Holding AG, Zug, Switzerland) and the same high resolution linear transducer of 7.5–13 MHz were applied in all the cases. Size, shape, and characteristics of the hilum

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0899-7071/$ – see front matter © 2014 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.clinimag.2013.11.012

and of the cortex were taken into account and documented for each analyzed node.

Longitudinal and transverse diameters and the longitudinal to transverse (L/T) axis ratio were evaluated. Hilar and cortical thickness, cortical to hilar thickness ratio, the presence or the absence of an echogenic hilum and its characteristics (hyperechoic, hypoechoic, or partially hypoechoic) were also assessed. Moreover, the presence of cortical bulges was carefully investigated; these were defined as areas at least twice as thick as the adjacent cortex.

2.1. Statistical analysis

The normal distribution of the quantitative variables was tested by the Shapiro-Wilk test.

Lymph nodes characteristics were compared among the anatomical regions, between males and females, among age groups (determined by the median ≤52, >52 yrs) in each of the three nodal sites with analysis of variance (ANOVA) and 95% confidence interval (95% CI) for the difference of the means adjusted with Bonferroni method. Gender, detection and echogenicity of the hilum, focal cortical thickening had been compared among the different anatomical sites with chi-square test or Fisher exact test as appropriate. The significance level was set at 5%. All the analyses have been performed with SAS 9.2 for Windows (SAS Institute, Cary, NC, USA).

3. Results

The results relating to the different analyzed parameters are summarized in Table 1.

On the basis of the pathological changes detected in the examined lymph nodes, the following data emerged (Table 1 and 2):

1. Longitudinal diameter: it was significantly longer in cervical lymph nodes than in axillary and inguinal nodes (10.4±3.54 mm vs. 14.82±3.45 mm and 13.82±3.62 mm, respectively; $P<.0001$).
2. Transverse diameter: all groups of examined lymph nodes differed from each other; in particular, the transverse diameter was shorter in cervical lymph nodes than in inguinal nodes (3.41±1.31 mm vs. 5.10±1.25 mm, respectively; $P< 0001$), which in turn demonstrated a statistically significant shorter transverse diameter than axillary nodes (5.10±1.25 mm vs. 6.88±2.10 mm; $P<.0001$).
3. L/T ratio: cervical lymph nodes had the highest index, followed by inguinal and axillary nodes (3.22±1.08 vs. 2.72±0.61 vs. 2.21±0.53, respectively).
4. Focal thickening: cortical bulges were detected on 13 inguinal and 9 axillary lymph nodes (Fig. 1), in contrast to cervical lymph nodes, where this feature was found in only one case. The dimension of the focal thickening of the cervical node was 2.3 mm; the mean cortical bulge dimension was 2.84±0.88 mm at the axillary level and 2.72±0.43 mm at the inguinal level.
5. Hilum: the absence of a central echogenic hilum was recorded in 7 cervical lymph nodes, whereas it had always been identifiable in the other sites.
6. Hilum characteristics: the hilum was homogeneously hypoechoic in 20 axillary lymph nodes and in 2 inguinal lymph nodes (Fig. 2A); it was homogeneously hyperechoic in all cervical lymph nodes. An inhomogeneous hyperechoic pattern, due to the presence of focal hypoechoic areas, was detected in four axillary lymph nodes (Fig. 2B).
7. Hilum thickness: all groups differed one from the other, ($p < 0.0001$), cervical lymph nodes had a lower hilar thickness than axillary and inguinal nodes and these latter in turn demonstrated a lower thickness than axillary nodes (1.45±0.92 mm vs. 4.62±1.72 mm vs. 3.72±2.30 mm, respectively) (Table 2).
8. Cortical thickness: it was statistically different among the three preselected groups (1.15±0.82 mm vs. 1.57±0.81 mm vs. 1.37±0.76 mm corresponding respectively to cervical, axillary, and inguinal nodes; $P=.0369$).
9. Ratio hilum/cortex: the cervical lymph nodes index is at least half of the one of the other two groups, as they are characterized by a very low hilar thickness (1.42±0.75 vs. 3.42±1.65 vs. 3.11 vs. 1.66 respectively cervical, axillary and inguinal lymph nodes; $P<.0001$).
10. Gender: the mean longitudinal diameter of the inguinal lymph nodes was higher for males than for females, 14.88±3.42 mm and 12.72±3.18 mm respectively ($P=.0346$, difference=2.17, 95% CI from 0.1643 to 4.17).
11. Age: the mean cortical thickness of the inguinal lymph nodes was 1.62 mm in ≤52 years patients compared to 1.19 mm in

Table 1
Summary of the results obtained for the various parameters analyzed (D = diameter). All measures are expressed in mm

Group	Variable	*N*	Mean	S.D.	Minimum	Lower quartile	Median	Upper quartile	Maximum
Cervical	Age	49	49.92	15.02	18.00	38.00	49.00	63.00	85.00
	Longitudinal D	49	10.40	3.54	4.40	8.00	10.00	12.60	22.00
	Transverse D	49	3.41	1.31	1.40	2.60	3.20	4.00	7.30
	Ratio L/T	49	3.22	1.08	1.70	2.30	3.00	3.90	6.20
	Hilum thickness	49	1.45	0.92	0.00	1.00	1.40	1.90	4.10
	Cortical thickness	49	1.15	0.82	0.00	0.80	1.10	1.50	3.50
	Ratio hilum/cortex	42	1.42	0.75	0.40	0.90	1.28	1.70	4.20
	Focal thickness	1	2.3	-	-	-	-	-	-
Axillary	Age	49	51.04	9.49	35.00	43.00	51.00	58.00	71.00
	Longitudinal D	49	14.82	3.45	5.40	13.00	14.50	17.40	23.00
	Transverse D	49	6.88	2.10	3.00	5.40	6.40	8.20	12.00
	Ratio L/T	49	2.21	0.53	1.30	1.80	2.20	2.60	3.70
	Hilum thickness	49	4.62	1.72	1.80	3.50	4.40	5.70	9.00
	Cortical thickness	49	1.57	0.81	0.50	0.90	1.30	1.90	4.30
	Ratio hilum/cortex	49	3.42	1.65	0.60	2.20	3.20	4.40	8.30
	Focal thickness	9	2.84	0.88	2.00	2.20	2.50	3.20	4.70
Inguinal	Age	49	54.63	14.59	20.00	47.00	54.00	64.00	92.00
	Longitudinal D	49	13.82	3.62	7.70	11.90	13.60	16.30	23.00
	Transverse D	49	5.10	1.25	2.30	4.60	5.20	5.90	7.40
	Ratio L/T	49	2.72	0.61	1.40	2.20	2.80	3.20	4.00
	Hilum thickness	49	3.72	2.30	1.00	2.70	3.50	4.20	16.40
	Cortical thickness	49	1.37	0.76	0.50	0.80	1.20	1.50	4.40
	Ratio hilum/cortex	49	3.11	1.66	0.20	2.00	2.80	4.00	7.50
	Focal thickness	13	2.72	0.43	2.30	2.50	2.60	2.70	4.00