Computer-aided processing ultrasonic diagnostic images of the children lymph nodes at lymphomas and reactive hyperplasias

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Abstract

Purpose: The aim of our investigation is studying the quantitative indicators of the blood flow in LN of children and teenagers with the first discovered Hodgkin disease, non-Hodgkin's lymphoma and BL on the base of the computer-aided processing the ultrasonic diagnostic images.

Material and methods: Pathologically enlarged cervical lymph nodes were evaluated during the primary ultrasonic investigation of 65 children of both sexes of age from 2 to 17. Clinical (n=19 at benign lymphoadenopathy) and morphological (n=31 at Hodgkin's disease, n=9 at non-Hodgkin's lymphoma and n=6 at benign lymphoadenopathy) diagnosis verification was carried on with all patients. Maximal and minimal blood flow linear velocities in the main intranodal artery, resistance index and Color Pixel Density were determined. The program has been worked out for processing lymph nodes ultrasonic images obtained in one of four modes: gray scale; color flow mapping; power Doppler imaging; pulsed waved Doppler. The list of the measured parameters is defined in each mode.

Results: Were received results: 1) of the grayscale images analysis, 2) of the vascular patterns in a mode color flow mapping, 3) of the flow analysis and index of the intranodal resistive in the Hodgkin disease and lymphopathy. They confirm prospect of inclusion to the computer algorithm of differentiation lymphopathy and the affected lymph nodes of the information received by means of modern technologies of the diagnostic ultrasound at the time of acknowledgements of the morphological diagnosis. The developed method optimizing the description of the ultrasound image of the lymphatic tissue, allows to distinguish the signs in multistage process of classification with the purpose to achieve criteria of defeat in the lymphomas.

Conclusions: The work results consist in definition of the functional features being the pathognomic ones with the statistically acceptable probability at the differential diagnostics of lymphomas and reactive hyperplasias.

Key words: lymphoma, cervical lymph nodes, Doppler sonography, vascularity index, computer method of the data identification, children.

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Introduction

Prospects of the lymphatic system organs ultrasonic investigation are determined by high resolution of the diagnostic equipment of the 4th generation and new Doppler technologies. According to the data of Ying M. et al., the lymph nodes (LN) sizes increase causes increase of the velocity of intranodal blood flow without substantial change of the resistance of intranodal blood flow [1]. Lymphomas hold the fourth place in the morbidity; structure and make-up approximately 13% of all the cancer diseases in children of the Republic of Belarus [8]. In many works the authors confirm the possibility of differentiation of benign from malignant lesions of LN during estimation of the intranodal resistance – in LN malignant lesions the resistance index (RI) has values over 0.8 [2-5]. Other authors consider RI over 0.72 [6] to be the indicator of the LN malignant lesion. There exist attempts of determination of the qualitative differential-diagnostic indicators for differentiation of lymphomas and reactive benign lymphoadenopathy (BL) on the basis of the semi-quantitative and qualitative indicators such as the LN shape, differentiation in the hilar area, vascularity appears [7-9]. There exist works on application of the contrast study with harmonic strengthening in studying vascularity of LN lesions [10] and high sensitive power Doppler in estimation of the vascularity of benign LN [11]. Accepting the decision about the

necessity of the lymphoid tissue histologic study is defined by the data of both clinic and instrumental methods of investigation. There are only single works on investigation of the vascularity appear of malignant lesions LN in cases of lymphomas and BL LN in children.

The aim of our investigation is studying the quantitative indicators of the blood flow in LN of children and teenagers with the first discovered Hodgkin disease, non-Hodgkin's lymphoma and BL on the base of the computer-aided processing the ultrasonic diagnostic images.

Material and methods

Pathologically enlarged cervical lymph nodes were evaluated during the primary ultrasonic investigation of 65 children of both sexes of age from 2 to 17 (age 9.7±0.6), that was carried on using the Logiq 500 (GE MS, USA) device. Investigation was carried on using the high frequency (13 MHz) linear transducer in the triplex mode.

Clinical (n=19 at BL) and morphological (n=31 at Hodgkin's disease, n=9 at non-Hodgkin's lymphoma and n=6 at BL) diagnosis verification was carried on with all patients. In 50% of all cases at Hodgkin's disease the variant of nodal sclerosis was stated, in the other cases – the mixed-cellular variant or lymphoid predominance. In the group of patients with non-Hodgkin's diseases the T-cellular tumors were prevailing.

Ultrasonic images of the lymph nodes were obtained in the gray scale modes, color flow mapping and power Doppler imaging modes when the index (Color Pixel Density) [12] and the intranodal vascularization character were estimated. During the pulsed waved dopplergraphy the check volume was placed in the visualization zone in the mode of color mapping of the arterial vessel in the region of the enlarged LN hilar projection. Maximal (V_{max}) and minimal (V_{min}) blood flow linear velocities in the main intranodal artery and RI were determined.

The program has been worked out for processing lymph nodes ultrasonic images obtained in one of four modes: gray scale (GRAY); color flow mapping (CFM); power Doppler imaging (PDI); pulsed waved Doppler (PWD). The list of the measured parameters is defined in each mode.

When opening the ultrasonic image the program, using the preliminarily trained neural network [13-15], automatically recognizes the operation modes of the ultrasonic diagnostic device, its settings, scaling coefficient. The recognized parameters are displayed on the input parameters panel and are supervised by a doctor-researcher. If necessary, e.g. in the case of erroneous recognition, the parameters can be edited in the manual mode. To start processing the doctor (operator) highlights the region of interest by a mouse and then initiates the processing mode by pressing the corresponding button on the modes control panel. After processing completion the results are displayed in the corresponding panel of the output parameters.

Statistical processing the data obtained was carried on using the standard methods. All the quantitative indicators after verification of the distribution normality are represented in the form M±m. Differences of the average values were considered reliable at p<0.05. The correlation analysis was carried out with calculation of the Pearson coefficient.

Results

The gray scale investigation of the LN in all the groups reflected their enlarged sizes, shape change, formation of the conglomerates, echogenicity reduction, the lack of the hilar region differentiation. The comparative analysis showed increase of the maximal longitudinal (L_1=32.3±2.4 mm) and cross (L_2=16.2±1.6 mm) dimensions for the LN in the non-Hodgkin's group in relation to the BL group (25.9±1.7 and 12.1±4.9 mm correspondingly, p<0.05). The most changed in a shape were the LN of the patients with the Hodgkin's diseases that is confirmed by the reliable reduction of the relation L_1/L_2 in comparison with the BL group (p<0.05) and is coordinated with the data of Papakonstantinou O. et al. [9].

The values of the blood flow linear velocities along the LN main artery for children with the BL exceeded those at Hodgkin's diseases (to the greater extent it was typical for V_{min}). The expressed differences in values of the blood flow finite diastolic velocity can indicate at more low intranodal blood flow resistance at BL that is confirmed by the RI values difference. The intranodal resistance of the circulatory bed of the patients with the non-Hodgkin's disease also exceeded the resistance for the BL group.

The L_2 and V_{min} correlation was noticed for children with the BL (r=0.44, p<0.05). The correlation was also obtained for L_2 and V_{max} and L_2 and V_{min} (r=0.83, r=0.78 correspondingly, p<0.05) for the patients with the non-Hodgkin's diseases that can reflect dependence of the intranodal circulatory bed properties from the degree of the lymphoproliferative process intensity. High resistance of the circulatory LN bed with the granulematosis lesion is evidently determined by its structure disorganization, presence of the diffuse fibrosis with the intranodal arterial network compression. Follicular hyperplasia at lymphadenopaties is accompanied by the small vessels proliferation that causes increase of the circulatory bed capacity and correspondingly reduction of its resistance.

The vascularity appear of the hyperplastic LN was characterized by the variety: from visualization of the short vascular pedicle at the hilar to visualization of the vascularity appear diffusion strengthening and tree-type structure with the foundation at the hilar region. Estimation of the Color Pixel Density indicator by the developed computer program showed its reduction in the group of patients with Hodgkin's disease relative to those with the BL (p<0.05). It is no necessary to note the variability of the intranodal vascularity appear in all the groups depending not only on the nosological and individual peculiarities of the concrete patient, but also on the diagnostic ultrasonic devise class and on its presenting.

Discussion and conclusions

The abilities of the computer-aided lymph nodes ultrasonic images processing at the reactive hyperplasias and lymphomas

in children are considered in the investigation. The technique is based on the ultrasonic images computer-aided analysis in the gray scale mode, color flow mapping and power Doppler imaging modes, estimation of the blood flow velocity characteristics and the intranodal resistance index in the mode of pulsed waved Doppler. The work results consist in definition of the functional features being the pathognomic ones with the statistically acceptable probability at the differential diagnostics of lymphomas and reactive hyperplasias.

The basic methods, which give the right for the lymphoma diagnosis formulation, are morphological and immunological investigations of the tumor substratum. The role and place of the ultrasonic method in the diagnostics of lymphomas in children are determined by the primary tumor localization and the tumor process spreading regularities [16]. Nevertheless, the data of the analysis of the blood flow linear velocity indicators, the circulation bed resistance and vascularization index confirm the perspective of differentiation of the reactive hyperplasia and lymphomas using the Doppler technologies by the moment of making the morphological diagnosis. These data can be applied as Doppler criteria in the differential diagnostics of the benign limphadenopathy and the malignant lymphoproliferative diseases in children on the stage of the primary diagnostics.

Acknowledgments

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