Research article

Quantitative analysis of cerebral alveolar echinococcosis and brain tuberculoma by MR diffusion weighted imaging

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Received 18 November 2015; revised 16 May 2016; accepted 16 May 2016
Available online 9 June 2016

Abstract

Objective: To explore the value of quantitative ADC in the identification and diagnosis of cerebral alveolar echinococcosis and tuberculoma.

Materials and methods: Patients admitted to our hospital from 2010 to 2014 with diagnosis of cerebral alveolar echinococcosis and tuberculoma underwent 3.0T superconducting MRI including whole brain routine MR plain scanning, enhanced scanning and DWI examination. The b-value for the DWI gradient sensitive factor is taken as 1000 s/mm². The apparent diffusion coefficient in the lesion solid area, the area around the edema and the brain normal solid area on the corresponding opposite location (control area) were measured respectively. The SPSS 17.0 software was used for statistics, and changes in the ADC values in the both pathologic lesion solid area and the area around the edema area were analyzed.

Results: The median and inter quartile range (IQR) of the ADC values of solid area of the cerebral alveolar echinococcosis and the brain tuberculoma lesion were: 1.08 x 10⁻³ mm²/s (1.03–1.13), 1.28 x 10⁻³ mm²/s (1.19–1.34), there was the significant difference between the average ADC values of the solid area of both diseases (t=5.435, P < 0.01); The median and IQR of edema area of the ADC values of the cerebral alveolar echinococcosis and the brain tuberculoma lesion were: 1.08 x 10⁻³ mm²/s (0.99–1.19), 1.39 x 10⁻³ mm²/s (1.23–1.49), there were the significant difference between average ADC difference around the edema area of both diseases (t=6.191, p < 0.05); No statistical significance was shown when the ADC value of the edema area of cerebral alveolar echinococcosis was compared to the ADC value of the solid area (p > 0.05). The ADC values of solid area and the area around the edema of the brain tuberculoma were higher than that of the corresponding area of the cerebral alveolar echinococcosis.

Conclusions: DWI combined with conventional MRI might be applied to provide valuable information for the diagnosis of the cerebral alveolar echinococcosis and the brain tuberculoma.

Keywords: Cerebral; Alveolar echinococcosis; Tuberculoma; DWI; ADC value

1. Introduction

Alveolar echinococcosis, caused by the larval stage of parasite echinococcus multilocularis, is a parasitic infection that affects both human and livestock [1]. Liver is the most target organ and other organs are rarely seen. Human AE continues to be a major health issue around the world including China, Western Europe, North Africa, and Middle East. Xinjiang region of China is one of the most prevalent area due to the scale of pastoral and semi-pastoral area [2]. Although rarely seen, cerebral AE present a lethal clinical outcome if untreated [3].

In recent years, the incidence of brain tuberculoma has increased slightly, most of them are secondary to pulmonary tuberculosis [4], with the space-occupying lesion covering from 5% to 30% of the central nervous system [5]. Although MRI of the brain tuberculoma has a certain characteristic appearance [5,6], CAE present a similar appearance as the conventional MRI of brain tuberculoma. Therefore, it is difficult to
differentiate two entities with conventional imaging examination. With the rapid development in molecular imaging, diffusion-weighted imaging (DWI) has developed rapidly, it is always used in the differential diagnosis of many diseases, for example tuberculoma, glioma toxoplasma and so on [7]. It could detect the diffusion of water molecules in living body tissues without as noninvasive method. To some extent, it could reflect the micro movement of water molecules in living body tissues under both physiological and pathological conditions.

The current research focuses on the quantitative analysis of solid area and the area around edema of both diseases by DWI and explores the effects of ADC values in the differentiation and diagnosis of cerebral AE and tuberculoma.

2. Materials and methods

2.1. General data

Ten patients with cerebral AE and 21 patients with tuberculoma were admitted in the first hospital affiliated of the Xinjiang Medical University from 2010 to 2014 (mean age 39 year; 13 men and 7 women). This study has been approved by the Clinical Ethical Committee of the First Affiliated Hospital of Xinjiang Medical University. Informed consents have been signed by each study subjects. The diagnosis of cerebral AE has been pathologically confirmed, while, the diagnosis of cerebral tuberculoma has been confirmed by surgical pathology or cerebrospinal fluid puncture without prior to medical treatment.

2.2. MR imaging and image processing

For imaging and collection, subjects were examined under the Signa HDX 3.0T Dual Gradient superconduction MR scanner with 8 channel phased-array surface coil pairs (manufactured by GE Company, USA). During the examination, the heads are fixed and earplugs were applied to shield noises. Conventional scanning axial, sagittal and coronal view were engaged in collecting T1WI, T2WI and T2FLAIR images. T1FLAIR images were used for enhanced scanning. Gadopentetate Dimeglumine (trade name: Magnevist solution; manufactured by Bayer Schering Pharma AG., Germany), was used as a strong scanning developer with an injection volume of 0.1 mg/kg. It was applied through intravenous injection.

The spin echo-plane echo series was applied in the DWI with a layer thickness of 5.0 cm, a layer gap of 0.0 cm, a layer number of 26, FOV of 24 cm, NEX 2, a matrix of 128 × 128, TR of 6000 ms, TE of 60 ms and a gradient sensitivity factor of 1000 s/mm². The diffusion gradients have been applied with the layer selection, phase encoding and frequency encoding.

All the images and data were evaluated separately by two senior neuro-radiologists. The GE ADW4.4 advanced image post-treatment work station along with the GE Function Tool 6.3 post-treatment software Functool. The ADC Figures combination with the routine MRI, DWI and ADC pseudocolor figures. Select the maximum level of T1 Flair enhanced images of lesion and the T2 Flair radial line defined the region of interest. It measured the cerebral alveolar echinococcosis, brain tuberculoma solid area and the edema area 10 mm around the lesion respectively as well as the ADC values in the normal cerebral white matter area in the opposite corresponding positions. Three ROIs were selected for each area. The size of the ROI depends on the size of the lesion as well as the limits of the exclusion criteria, according to the measurement of multiple sets of data, we decided to give a certain range of ROI (11–22 mm²) and the average of three ADC values was taken. The lesions with a diameter larger than 5 mm were selected. (Figs 1 and 2)

2.3. Statistical analysis

The SPSS17.0 statistical analysis software package was used in the study. The ADC values of lesion solid area, the area around the edema as well as the control area were retrospectively assessed. The above values of four groups were compared using Kruskal–Wallis test. Statistical significance was considered when p value was less than 0.05.

3. Results

3.1. MRI expressions

There are 21 effective lesions located in the brain cortex or subcortex in the 10 case cases of this group, and the lesions are irregular in shape with uneven signal. In the solid area, T1WI show hyperintense or isointense signals, The T2WI show hypointense or isointens signals. Such lesion characteristics are present as long the T2 signals are inside the lesion vesicular shape. In the DWI graph, it appeared as a mix of both high and low signals. It appeared as slightly higher ring-shaped signals around parts of the lesion. There are uneven edema rings around the lesion. In the T2Flair sequences, it appeared as slightly higher signals. After the enhanced scanning, the lesion showed irregular strengthening.

In the cases of brain tuberculoma, there are also 21 effective edema located in the junctions of the gray and white cortex and basal ganglia region, a part of which is located in the cerebellar hemispheres and brainstem, appearing as multiple uneven nodules or lumpy shadows in various sizes. The T1WI lesion appeared to be hyperintense or isointense signals and the T2WI appeared to be hypointense or isointens signals. Visible short signal rings are seen in the peripheral parts around which there appeared irregular slices of edema. In the DWI sequences, there appeared to be slightly lower signals or a mix of high and low signals. After enhancement, the lesion showed irregular ring-shaped nodular strengthening. (Table 1)

3.2. The comparison between the average ADC values of the 10 cases of cerebral alveolar echinococcosis and brain tuberculoma with 21 effective lesions in total
4. Discussion

The basic pathological characteristics of cerebral AE are presented with numerous small vesicles in budding proliferation which appear as grape-shaped cellular changes. Featured by its “tumor-like” growth, small vesicles around cerebral AE lesion incessantly grow, expand and proliferate, consequently, eroding cerebral tissues. The extension of the lesion to the brain tissue is characterized as “crab claws”, which is extremely dangerous to the human body. The early stage of cerebral AE lesion is shown as proliferative granuloma changes. The solid area lesions under pathological microscope are mainly scattered or clustered micro-vesicles and the cuticular plate of the vesicles are incomplete in development. The germinal layer proliferates in both internal and external budding (internal budding and external budding). Most of the cerebral AE developed relatively rapidly and are like malignant tumors.

Brain tuberculoma is the formation of chronic granuloma lesion caused by *mycobacterium tuberculosis* scattered within the brain solid area. Its pathological basis is the tubercle, which is the proliferative granuloma lesion caused by allergic reaction mainly by T lymphocytes. During the early stage, it is mainly shown as inflammatory exudation. During the

<table>
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<tr>
<th>Classification</th>
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<th>Solid area</th>
<th>Edema area</th>
<th>Control area</th>
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<tr>
<td></td>
<td>M</td>
<td>P_{25}–P_{75}</td>
<td>M</td>
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<tr>
<td>CAE</td>
<td>21</td>
<td>1.08</td>
<td>1.03–1.13</td>
<td>1.08</td>
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<td>Brain tuberculoma</td>
<td>21</td>
<td>1.28</td>
<td>1.19–1.34</td>
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Note: The statistical significance difference was found in comparison of ADC values between cerebral AE solid area and control area (P < 0.05). However, no statistical significance was found in the comparison of ADC values between cerebral AE edema area and solid area (P > 0.05). The statistical significance was also found among the ADC values of brain tuberculoma lesion solid area, the edema area around as well as the control area (P < 0.05). The comparison of the ADC values between cerebral alveolar echinococcosis and brain tuberculoma solid area Showed statistical significance (t = 5.435, P < 0.05). Besides, the statistical significance was shown in the comparison of the ADC values between cerebral AE and brain tuberculoma edema areas (t = 6.191, P < 0.05).
advanced stage, integral fibrous capsule are formed around the tuberculoma in the central area. Lipid-like cheese necrosis occurs, and there is a tuberculoma wall around the cheese necrosis which is made up of epithelioid cell, langhans giant cells, lymphocytes, fibroblast and collagenous fiber. In current study, brain tuberculoma solid area includes the whole tuberculoma itself which is immature and mature tuberculoma caseous necrosis of peripheral wall.

The DWI could reflect the micro movement of water molecules in the living body. Not only it could envelope the spatial formation of various structures of the human body at the molecular level, it could also reflect the functional changes of various tissues under pathological and physiological conditions. Furthermore, it could demonstrate the early changes of morphology and physiology related to water content in the tissues. Influenced by T2 tissue penetration effect, the morphology and physiology related to water content in the tissues [8]. Influenced by T2 tissue penetration effect, the amplitude of the DWI signal sometimes not truly reflected the speed of the changes of molecular expansion in the tissues under pathological conditions. Therefore, the ADC values could often be taken as the quantitative indices for water molecular expansion, which is used to describe the diffusion of water molecules in living tissues. The DWI signals influencing lesion and factors influencing the ADC values are mainly the quantity, sizes and arrangement of cells, the number and size of the organelle in the cells and the intercellular spaces, etc. The greater the number of cells is, the tighter the cell arrangement and the smaller the cell spaces, and thus the slower the diffusion of water molecules in the cells.

In current study, cerebral tuberculoma displayed significantly higher averaged ADC value in solid area than cerebral AE. This result might be attributed to distinct pathological disparity and interpreted as follows: Firstly, the brain tuberculoma body is a inflammatory granulation tissue that contains inflammatory cells, fibroblast cells and collagenous fibers. Meanwhile, due to the tuber sourced edema that result in the expansion of intercellular spaces, the water molecules expand rapidly, with the increase in the ADC values [9]. Secondly, cerebral AE has numerous concentrated vesicles and vesicular groups that are densely arranged, resulting in the shrinkage of intercellular spaces, and the expansion of water molecules are limited. Thirdly, since cerebral AE have numerous vesicles and vesicular groups, the more they are in need of energy, the larger the number of organelle within the cells, and the more evident the limitation of water molecular diffusion.

Cerebral AE and tuberculoma lesion both demonstrated long T1 and T2 signals in edema around the lesion, and there is no strengthening shown in the enhanced scanning. The ADC values of brain tuberculoma edema around the lesion is higher than the ADC values of the Cerebral AE edema around the lesion, and the author concluded through analysis that the difference between the water molecular diffusion in both cases may lie in the differences between the pathological structure of both cases. The brain tuberculoma edema area is mainly the edema of blood vessels caused by multiple inflammation mediators secreted by the inflammatory cells [10]. While cerebral AE has the characteristics of infiltrated growth features [11], the edema around lesion are also partly caused by E. multilocularis infiltration apart from the blood vessel sourced edema. It hinders the water molecular diffusion to certain extent, resulting in the decrease of the ADC values.

In the current research, it is also discovered that the comparison of the CAE solid area with the ADC values around the edema area has no statistical significance, while the differences found in the comparison of the solid area with the ADC values of the control area and the edema area with the ADC values of the control have statistical significance. This further suggests that lesion solid area and brain solid area near edema area may possibly be homogeneous, i.e. the cerebral AE lesion boundary zone has E. multilocularis infiltration [11].

This research applied the high b-value diffusion-weighted imaging technique to carry out quantitative index analysis and the exploration for ACE and Brain tuberculoma. The main body of lesion in this research selected significantly strengthened lesion solid area after enhancement. Both diseases have proliferative lesion, the ingredients of which are representative. However, in this research, the case samples for preliminary exploration are small, and with the increase in the number of cases, it has become the focus of the further research of different stages and different subtypes for in-depth analyses. In addition, through the combination of pathology and determination of quantitative indices for the neighboring zones, the middle zones and the distant zones of the cerebral AE edema area, the question of whether or not the cerebral AE infiltration growth makes a difference in its distance could be further explored.

**Foundation items**

The Natural Science Foundation of the Xinjiang Uygur Autonomous Region (2011211A072).

The National Natural Science Foundation of China (No. 30860268).

**References**


