Research Article

Diffusion-Weighted MR Imaging in Evaluation of Malignant Lymphoma and Squamous Cell Carcinoma in the Head and Neck Regions

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Abstract

Objective: The aim of this study was to evaluate malignant lymphoma and SCC in head and neck region with diffusion-weighted MRI. **Patients and methods:** Twenty two patients with histologically proven, untreated head and neck malignant lymphoma and SCC underwent DW-MRIs with b values 0, 1000 s/mm^2 besides morphological sequences and corresponding ADC maps were generated. The mean ADCs were measured for both groups. We also measured ADC values of spinal cord and cerebrospinal fluid (CSF) in the upper neck area which served as an internal control. The diagnostic performance of DW- was evaluated by sensitivity and specificity at the optimum cutoff point and the area under the receiver operating characteristic curve. **Result:** The mean ADC for ML ($0.76 \pm 0.09 \times 10^{-3}$ mm^2/s) was significantly lower than that for HNSCC ($1.03 \pm 0.2 \times 10^{-3}$ mm^2/s, $p<0.0001$) (Table 2). A threshold ADC value of $> 0.83 \times 10^{-3}$ mm^2/s could be used to discriminate HNSCC from ML, with highest accuracy of 95.5 %, plus 90 % sensitivity, 100 % specificity, 100 % PPV, and 91.7 % NPV. **Conclusion:** Diffusion-weighted MRI when used in combination with conventional MRI techniques in head and neck imaging, provides clinically important information. The ADCs were a powerful tool for differentiating between ML and SCC. ADC values of lymphoma were significantly lower than those of SCC.

Key words: Malignant lymphoma, squamous cell carcinoma, DW-MRI, ADC, p-value.

Introduction

Diagnosis of the head and neck lesions is difficult due to the complicated anatomic structure and different histological components of the many tissues that the neck contains. SCC is the most common primary malignancy of the head and neck. It represents almost 90% of the head and neck tumors (HNSCC) and it shows different biological behaviors according to location. Malignant Lymphoma (ML) is also common, it is the second most common malignant tumor of the head and neck and represent approximately 5% of all malignant neoplasms of the head and neck 0area.[1,2]

There are no specific characteristics for the manifestations and clinical behavior of lymphomas and SCC in the head and neck region that would help in the diagnosis without biopsy and histological evidence. Pretreatment imaging evaluation of these two malignant tumors is very important for tumor staging and treatment planning, because the management of them is radically different.[3,4]

Magnetic resonance imaging (MRI) is effective for diagnosing tumors, it can not only define tumor's locoregional extension, it provides additional information on tumor extension, muscles and lymph nodes involvement, and skull base and intracranial invasion, but, both T1-weighted imaging (T1WI) and T2-weighted imaging (T2WI) may show equal signaling characteristics for both tumors. Thus, it is sometimes very difficult to clinically differentiate HNSCC from lymphoma on the basis of conventional MRI alone.[5,6]

Diffusion-weighted MR imaging (DWI) is a non-invasive functional technique with short sequence produced by echo-planar imaging (EPI) and fast advanced spin echo sequences. DWI allows visualization of microscopic motion of water molecules within tissue, so any changes in water diffusivity will alter the apparent diffusion coefficient (ADC) and the signal intensity in DWI and apparent diffusion coefficient maps. The main advantage of DWI appeared to be the sensitivity to microscopic pathologic alterations before they became visible on conventional MRI sequences.[7,8]

The aim of this study was to evaluate head and neck SCC and malignant lymphomas with diffusion-weighted MRI.

Patients and Methods

Patient selection:

Twenty two patients were selected from the outpatient clinics of El Minia Oncology Center who were suffering from suspected malignancies in head and neck area from period of November 2018 to August 2020 according to the inclusion criteria which were recently affected patients with proven malignant lymphoma or SCC in head and neck region. Exclusion criteria were patients with other types of malignancies rather than lymphoma or SCC, Patients who received radiation therapy, chemotherapy, or both before MR study, recurrent cases. The study population included eleven patients with SCC (with mean age 58.4 years) and eleven patients with ML (with mean age 52.5 years)

This study was approved by the Research Ethics Committee (REC) under number 315/ 2018, Faculty of Dentistry, Minia University before starting the research. Written, informed consent was obtained for all participants.

Patient history and clinical examination

Detailed case history and thorough extra- and intra-oral examinations of the patients were performed to determine the presence of swelling, tenderness, ulcerations, asymmetry or edema. A final diagnosis of all patients was based on conventional histopathological studies; the specimen was achieved either by true cut guided biopsy (n =14, 63.6%), or by excisional biopsy (n =8, 36.3%).

MRI examinations

Patients were examined using a 1.5-T MR unit (Achieva; Philips Medical Systems, Best, the Netherlands). Routine MRI examinations were done with slice thickness 4mm, interslice gap of 1mm; the matrix used for all sequences was 512 × 256, field of view 27 x 27 cm, number of acquisitions NEX 2, pixel resolution 0.7 x 1.1 x 4.0 mm), with following parameters: T1 weighted sequence (repetition time [TR] 600–663ms, time to echo [TE] 10–12 ms). T2 weighted sequence (TR 4000-6800 ms, TE 80–100 ms). The single-shot echo-planar DW-MRI in the axial plane was obtained at (b = 0 and 1000 s/mm^2, TR 2169 ms, TE 73ms, matrix size 192 x 182, section thickness 5. 0 mm, gap 1 mm, field of view 27 x 27 cm, pixel resolution 1.5 x 1.5x 4.0).

Image analysis:

The ADC maps were generated on the GE Medical Systems workstation. The regions of interest (ROI) were drawn manually on the ADC maps at b=1000 s/mm^2, with references to T2-weighted images and T1-weighted images. We measured a region of interest (ROI) with a median size of 25 mm^2 from the solid portion of the mass, we avoided cystic or necrotic parts that might influence the ADC values. We also measured ADC values of spinal cord and cerebrospinal fluid (CSF) in the upper neck area which served as control group.

Statistical Analysis

Numerical data were presented as mean and standard deviation (SD) values. Repeated measures ANOVA test was used to compare between ADC values in the two groups. ROC curve analysis was performed with MedCalc® Statistical Software version 19.5.1 (MedCalc Software Ltd, Ostend). The significance level was set at P $\leq$0.05. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

Results

The mean ADC for ML (0.76 ± 0.09 x 10^{-3} mm^2/s) was significantly lower than that for HNSCC (1.03 ± 0.2 x 10^{-3} mm^2/s, p<0.0001) (Table 2). A threshold ADC value of > 0.83 x 10^{-3} mm^2/s could be used to discriminate HNSCC from ML, with highest accuracy of 95.5%, plus 90% sensitivity, 100% specificity, 100% PPV, and 91.7% NPV.

No significant differences in the mean ADCs of the CSF and spinal cord were seen among the two groups (Table 3). The mean ADCs of the CSF and spinal cord in all 22 patients were (2.94 ± 0.47 x 10^{-3} mm^2/s and 1.12 ± 0.15 x 10^{-3} mm^2/s), respectively.

Table (1): Descriptive statistics and results of repeated measures ANOVA test for comparison between ADC values (mm^2/s) in the two groups.

	Mean ($x10^{-3}$ mm^2/s)	SD ($x10^{-3}$ mm^2/s)	***P*-value (Between groups)**	**Effect size *(Partial Eta Squared)***
HNSCC (n = 11)	1.03 (0.99- 1.40)	0.2	<0.001*	0.591
ML (n = 11)	0.76 (0.53- 0.73)	0.09		

Table (2) comparison between ADC values (mm^2/s) in carcinoma and ML groups compared to normal values (CSF and spinal cord).

	ADC values		**Normal CSF (n = 11)**		**Normal spinal cord (n = 11)**		***P*-value**	**Effect size *(Partial Eta Squared)***
	Mean x 10^{-3}	**SD x 10^{-3}**	**Mean x 10^{-3}**	**SD x 10^{-3}**	**Mean x 10^{-3}**	**SD x 10^{-3}**		
HNSCC (n=11)	1.03	0.2	3.02	0.53	1.15	0.19	0.018*	0.444
ML (n=11)	0.67	0.09	2.86	0.42	1.09	0.11	<0.001*	0.972

*: Significant at $P \leq 0.05$.

Discussion

The most common head and neck malignancies are squamous cell carcinoma followed by lymphomas. Conventional MR imaging findings are often nonspecific for SCC versus lymphoma. As the management is different for these two different groups of malignancies, it is important to clearly distinguish them from each other. Yet, imaging supplemented with DWI may be a powerful tool as it give not only morphological details, but also biological and functional information, so, it may provide the physicians as to which one of malignancies they might be dealing with.

In this study SCC showed statistically significantly higher mean ADC value (1.03±0.20 $x10^{-3}$ mm^2/sec) than lymphoma (0.67± 0.09 x 10^{-3} mm^2/sec) which is in agreement with the findings of Tomoko et al., 2016[(9)] and Wang et al., 2001[(10)] who reported that ML had smaller mean ADCs than SCC using the high b-factor of 1000 s/mm^2. In addition, Ichikawa et al., 2012[(11)] stated that oropharyngeal carcinomas showed higher ADC value than lymphoma. However, they reported that discrimination of nasopharyngeal carcinomas from lymphoma based on ADC values was very difficult due to histological similarity of nasopharyngeal carcinomas and lymphomas. Also, Chawla S et al., 2009[(12)], Herneth AM et al., 2010[(13)] and Thoeny HC et al., 2012[(14)] reported the usefulness of the ADC values in the differentiation of both SCC and lymphoma and stated that mean ADC values of SCC were significantly larger than those in lymphomas.

Maeda et al., 2005[(15)] measured the ADCs using line scan DW imaging (LSDWI) with b-factors 5, 1000 reported that ADC values were (0.96 ± 0.11 $x10^{-3}$ mm^2/sec) for SCC and (0.65 ± 0.09 $x10^{-3}$ mm^2/sec) for lymphoma and the difference was significant. Also, D.Fong et al., 2010[(16)] found that a statistically significant difference, was found between non Hodgkin lymphoma and SCC which is in agreement with this study.

Gonçalves FG et al., 2011[(17)] and Wang et al., 2001[(10)] explained that the tissue DWI signal intensity is dependent on the microstructure and physiologic state of the tissues, because the diffusion of water proton in biologic tissues depends on the diffusion of intracellular water molecules, water protons passing through cell membranes, and extracellular water. Water motion can be disturbed by intracellular organelles, fibers and macromolecules in the tissues. Any change occurs in tissue components, including a change in the ratio of extracellular to intracellular water protons, will lead to altering the diffusion coefficient of the tissue. Malignant lymphomas in general have more cellularity, larger and more angulated nuclei and less extracellular space than SCC resulting in greater diffusion restriction and lower ADC values than SCC.

In this study Receiver operating characteristic (ROC) curve analysis showed that an ADC value of 0.83 x 10^{-3} mm^2/s can discriminate between SCC and ML with 95.5% diagnostic accuracy, a sensitivity of 90.9% and specificity of 100% which is in agreement with Wang et al., 2001(10), Tomoko et al., 2016(9) and Vidiri A et al., 2019(18) who set an ADC threshold of 0.84 x10^{-3} mm^2/s, 0.89 x10^{-3} mm^2/s and 0.83 x 10^{-3} mm^2/s respectively to discriminate between these two lesions. On the contrary, Ichikawa et al., 2012(11) set a cut off ADC value of 0.66 x 10^{-3} mm2/s which discriminated oropharyngeal lymphomas from SCCs with higher sensitivity 100% and lower specificity 88%, 93% accuracy, and 85% positive and 100% negative predictive values. Also, Maeda et al., 2005(15) reported a threshold ADC of 0.76 x10^{-3} mm^2/s for the differentiation between the two entities which produced a very high accuracy of 98%.

Conclusion

Diffusion-weighted MRI when used in combination with conventional MRI techniques in head and neck imaging, provides clinically important information. The ADCs were a powerful tool for differentiating between ML and SCC. ADC values of lymphoma were significantly lower than those of SCC.

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