European Journal of Radiology 106 (2018) 7–13

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Histogram analysis of apparent diffusion coefficient maps in the prognosis of patients with locally advanced head and neck squamous cell carcinoma: Comparison of different region of interest selection methods

Ji-Liang Ren[1], Ying Yuan[1], Xiao-Xia Li, Yi-Qian Shi, Xiao-Feng Tao*

Department of Radiology, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai 200011, China

ARTICLE INFO

Keywords:
Head and neck cancer
Prognosis
Magnetic resonance imaging
Apparent diffusion coefficient
Histogram analysis

ABSTRACT

Objective: To investigate the influence of different region of interest (ROI) selection methods on the histogram analysis of apparent diffusion coefficient (ADC) maps and to compare their performance in predicting overall survival (OS) in patients with locally advanced head and neck squamous cell carcinoma (HNSCC).

Methods: A total of 73 patients with locally advanced HNSCC who underwent pretreatment diffusion-weighted magnetic resonance imaging were included. Based on the largest slice ROI (ROI_{LS}) and whole tumor ROI (ROI_{WT}), ADC histogram parameters including mean ADC (ADC_{mean}); median ADC (ADC_{median}); 10th, 25th, 75th, and 90th percentiles of ADC values (ADC_{10}, ADC_{25}, ADC_{75}, and ADC_{90}); kurtosis; and skewness were obtained. Intraclass correlation coefficients (ICCs) and Bland–Altman plots were used to evaluate measurement reproducibility. The association of ADC histogram parameters and clinicopathological factors with OS was analyzed using log-rank tests and Cox regression.

Results: The measurements of ADC histogram parameters based on ROI_{WT} showed better reproducibility than ROI_{LS} (ICCs for ROI_{WT}: 0.772–0.961; ICCs for ROI_{LS}: 0.511–0.851). The higher ADC values (ADC_{mean}, ADC_{median}, ADC_{10}, and ADC_{25} based on both ROIs; ADC75 based on ROI_{LS}) and lower kurtosis based on ROI_{LS} were significantly associated with worse OS of patients with locally advanced HNSCC (all $P < 0.05$). In the multivariate Cox analysis, ADC_{10} measured with ROI_{WT} ($P = 0.019$, hazard ratio = 2.63, 95% confidence interval 1.17–5.90) was an independent prognostic factor after adjusting for clinicopathological factors.

Conclusions: ROI selection methods could influence ADC histogram analysis. ADC_{10} based on ROI_{WT} had the best independent prognostic value for patients with locally advanced HNSCC.

1. Introduction

Head and neck squamous cell carcinoma (HNSCC) accounts for over 90% of malignant head and neck tumors in adults, and nearly two-thirds of patients present at a locally advanced stage [1,2]. Identification of patients at risk of poor outcome may help avoid unnecessary surgery and facilitate the development of personalized management to improve clinical outcomes. Currently, most clinically acceptable prognostic factors for locally advanced HNSCC are tumor-node-metastasis (TNM) stage, histological grade, and human papilloma virus (HPV) status [3]. Genetic profiles and RNA/protein tumor expression profiles were also suggested as potential biomarkers associated with the survival of locally advanced HNSCC patients [4]. However, easily obtainable pretreatment biomarkers for prognostic assessment are still lacking.

Diffusion-weighted (DW) magnetic resonance imaging (MRI) allows for quantification of water molecular motion with the apparent diffusion coefficient (ADC). In oncology, DW imaging is a promising technique with the potential to predict clinical outcome. Previous studies have indicated that mean ADC is significantly associated with prognosis in HNSCC [5–7]. However, the mean ADC may not represent the full spectrum of histology within a tumor. The approach of ADC histogram analysis better reflects the variable components and heterogeneity within the tumor, and could therefore provide more information than conventional mean ADC. King et al. [8] reported that pretreatment ADC histogram analysis could help predict treatment response to radiotherapy or chemotherapy in patients with advanced HNSCC.

Previous studies of ADC histogram analysis mostly adopted two region of interest (ROI) selection methods: ROI covering the largest slice (ROI_{LS}) and ROI covering the whole tumor (ROI_{WT}) [9–13]. Others

* Corresponding author.
E-mail address: cjr.taoxiaofeng@vip.163.com (X.-F. Tao).
[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.ejrad.2018.07.004
Received 2 January 2018; Received in revised form 24 May 2018; Accepted 3 July 2018

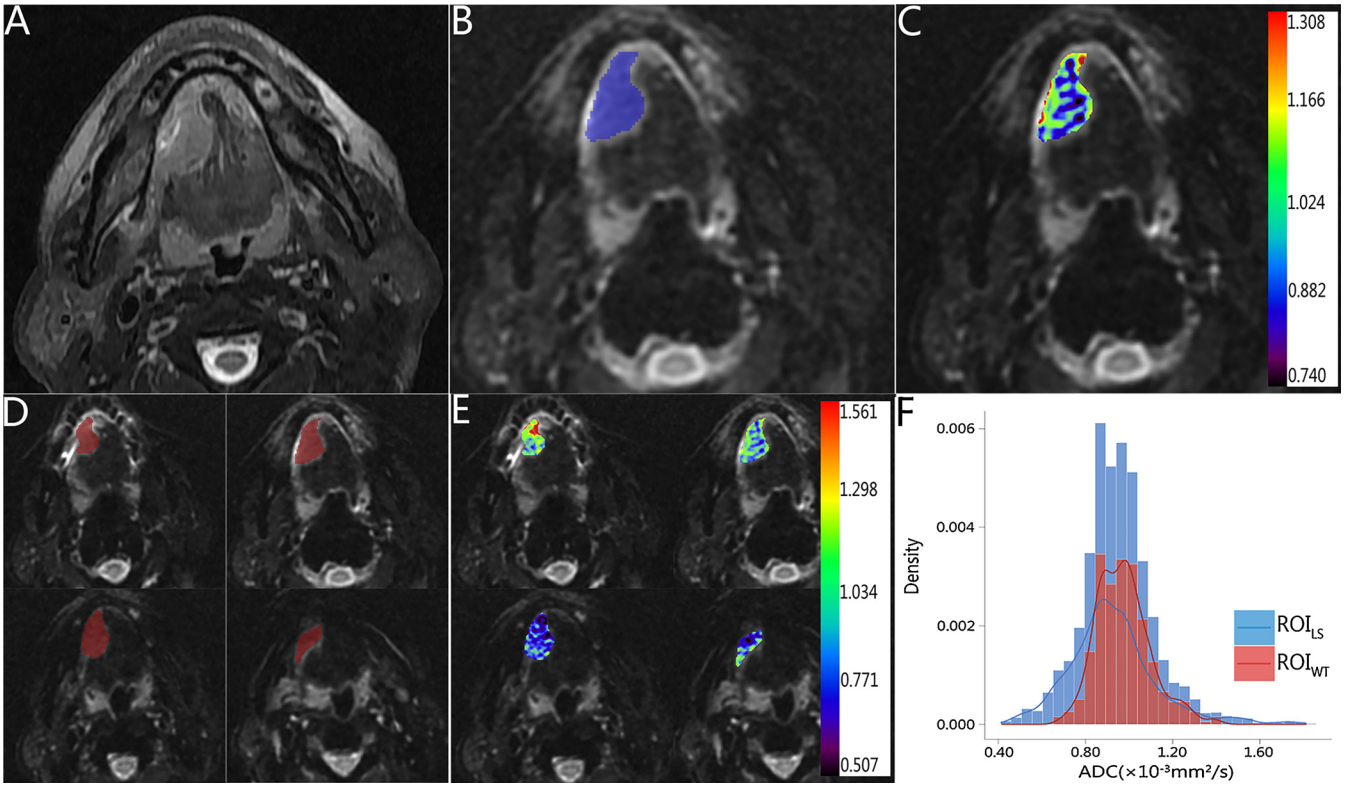

Fig. 1. Schematic illustration of two ROI selection methods on DW images (b = 0 s/mm^2) obtained from a patient with stage IV head and neck squamous carcinoma. Axial T2-weighted image shows a lesion located in right mouth floor (A). ROI_{LS} was defined by covering as much tumor tissue as possible in the slice with maximum diameter (B). ROI_{WT} was placed along border of tumor on all slices where the tumor can be visualized (D). The corresponding ADC maps for ROI_{LS} (C) and ROI_{WT} (E) could be generated and embed within DW images. ADC histogram could be obtained based on the two different ROIs, which was used to generate corresponding parameters, including mean ADC, median ADC, 10th, 25th, 75th, 90th percentiles of ADC values, kurtosis and skewness (F). ROI: regions of interest; DW: diffusion weighted; ADC: apparent diffusion coefficient.

Table 1
Patient characteristics.

Characteristic	Value
Sex	
Male	48 (66)
Female	25 (34)
Age*	57.9 ± 12.2
Tobacco use	
Yes	26 (36)
No	47 (64)
Alcohol use	
Yes	22 (30)
No	51 (70)
Primary mass location	
Oral cavity	57 (78)
Oralpharynx	16 (22)
T stage	
1–2	32 (44)
3–4	41 (56)
N stage	
0	15 (21)
1	22 (30)
2	36 (49)
Overall stage	
III	19 (26)
IV	54 (74)
Follow-up time(day)	
Median	767
Maxium	1516

Values are N (%) unless otherwise indicated.
* Data are mean ± standard deviation.

have reported that ADC measurement can be affected by ROI selection method [14,15]. However, to our knowledge, the influence of the two different ROI selection methods on ADC histogram analysis in HNSCC has not been evaluated.

The aim of the present study was to investigate the influence of different ROI selection methods on ADC histogram analysis and to compare the prognostic values of ADC histogram parameters in locally advanced HNSCC.

2. Methods

2.1. Patients

The study was approved by the local ethical institutional review board. Informed consent was waived for this retrospective study. A comprehensive search of our institutional database for medical records from July 2011 to April 2015 was performed to identify patients with HNSCC. Patients were included based on the following criteria: (1) postoperative pathology confirmed as HNSCC (TNM stage: III–IVb), (2) short axis of mass ≥10 mm, (3) underwent DW imaging less than 15 days before treatment, and (4) follow-up longer than 730 days in cases of living patients (censored). The exclusion criteria were: (1) any prior history of head and neck cancer, (2) received treatment before MR scanning, or (3) severe image susceptibility artifacts or motion artifacts on DW images.

Baseline clinical data were recorded, including patient demographic information (age, sex), treatment, risk factors (alcohol and tobacco use), and pathological TNM stage. Tumor stage was determined using the 7th American Joint Committee on Cancer (AJCC) TNM Staging System Manual. Overall survival (OS) was defined as the time from the