Introvoxel incoherent motion (IVIM) with multi-b values DWI in the diagnosis and grading of cervical cancer

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TARGET AUDIENCE

Anyone who interested in different models of diffusion weighted imaging (DWI) using multi b values or functional MRI of cervical cancer.

PURPOSE

To investigate the utility of intra-voxel incoherent motion model (IVIM) with multi-b values DWI in the diagnosis and grading of cervical cancer.

METHODS

54 female patients with cervical cancer prior to the treatment and 20 matched Healthy volunteers were recruited and underwent pelvic MR examination. DWI was acquired on the transverse plane with 10 b values (0, 30, 50, 100, 150, 200, 400, 800, 1000, 1500 s/mm^2). Parametric maps of standard ADC (ADC), slow ADC (D), fast ADC (D*) and perfusion fraction (F) were generated. ROIs encompassed the whole tumor area (ROI_all), tumor edge (ROI_peri) and tumor center (ROI_in) were defined in patient group, respectively, whereas ROIs were placed on normal cervixes in control group. To compare the quantitative parameters from cancer group with that from control group, as well as to compare the parameters of tumor edge with that of tumor center,nonparametric test of Mann-Whitney U test, Kruskal-Wallis H test and areas under receiver operating characteristic (ROC) curve were applied correspondingly.

RESULTS

1. 49 out of them were diagnosed with epithelial cancer, including 4 patients with Grade 1 tumor (G1), 35 with G2 and 10 with G3. 4 patients were diagnosed with adenocarcinoma. 3 of them were diagnosed with G2 and 1 with G3. Only 1 patient was diagnosed with adenosquamous carcinoma (G3).

Table 1 Quantitative parameters of cervical cancer and normal cervix (median and range)

Group (No. of cases)	Age	ADC ($\times10^{-3}$mm^2/s)	D($\times10^{-3}$mm^2/s)	D*($\times10^{-3}$mm^2/s)	F
Cancer (54)	47 (27-69)	0.89 (0.63-1.85)	0.71 (0.50-0.89)	11.50 (0.95-23.20)	0.19 (0.13-0.27)
Normal cervix (20)	42 (26-65)	1.44 (1.12-1.87)	1.10 (0.77-1.34)	7.46 (1.60-20.00)	0.43 (0.27-0.74)
χ^2	1.437	-6.257	-6.464	3.317	-6.574
P	0.151	0.000*	0.000*	0.001*	0.000*

*: *P*<0.05

2. ADC, D and f of cervical cancer within ROI_all were significantly lower than that of normal cervix ($P<0.001$), and D* of cervical cancer within ROI_all was significantly higher than that of normal cervix ($P=0.001$)(Table 1). Except for D*, all of the parameters were of good diagnostic performance. The areas under ROC curve of ADC, D, D* and f were 0.976, 0.992, 0.248 and 1.000, respectively (Figure 1). All of the DWI parameters of squamous carcinoma and adenocarcinoma were of no significant difference.

Table 2 Quantitative parameters within different region of cervical cancer (median and range)

Region of ROI	ADC ($\times10^{-3}$mm^2/s)	D($\times10^{-3}$mm^2/s)	D*($\times10^{-3}$mm^2/s)	F
ROI_peri	0.92 (0.66-2.17)	0.72 (0.53-0.89)	12.40 (0.99-24.67)	0.20 (0.13-0.29)
ROI_in	0.83 (0.56-1.54)	0.67 (0.43-0.94)	10.75 (0.78-21.7)	0.17 (0.10-0.25)
χ^2	-5.585	-4.611	-3.079	-5.456
P	0.000*	0.000*	0.002*	0.000*

*: *P*<0.05

3. ADC, D, D* and f of tumor edge were significantly higher than that of tumor center ($P<0.05$)(Table 2). ADC_in, D_all and f_peri among 3 grades of squamous carcinoma were significantly different. Pair-wise comparison showed statistic differences of D_all between G1 and G3 and f_peri between G2 and G3 ($P<0.05$), and all of the others were of no significant difference. ADC_in and D_all had negative correlation with tumor grading, f_peri had positive correlation with it ($P<0.05$), and all of the others were of no significant correlation. While diagnosing G3 tumors, the areas under ROC curve of ADC_in, D_all and f_peri were 0.713, 0.733 and 0.768, respectively. The cut-off values were 0.78, 0.6 and 0.22, which led to the highest Youden indies (Youden index = sensitivity + specificity - 1). The sensitivity was 75.0%, 75.0% and 66.7% and the specificity was 66.7%, 55.6% and 82.5% respectively. (Figure 2)

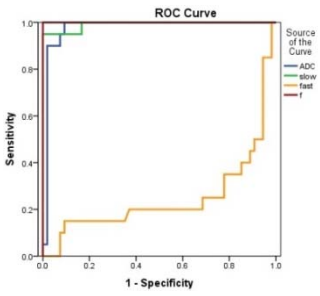

Figure 1. ROC curves for ADC, D, D* and f in differentiating cervical cancer from normal cervix.

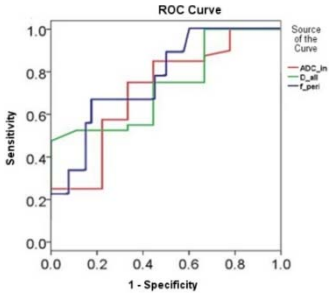

Figure 2. ROC curves for ADC_in, D_all and f_peri in differentiating G3 cervical cancer from G1 and G2 cervical cancer.

DISSCUSSION

Both mono-exponential model and IVIM model could help to differentiate cervical cancer from normal cervix. ADC, D and f showed good diagnostic performance. The parameters of diffusion and perfusion at tumor edge were higher than those at tumor center. It could be inferred that cervical cancer had a heterogeneity character, and the low perfusion at tumor center might be caused by relatively shortage of blood supply while tumor grew rapidly. No significant difference was found between squamous carcinoma and adenocarcinoma. As there were only a few samples of adenocarcinoma, further studies may be needed. Comparing with mono-exponential model, IVIM model may play a more important role in tumor grading, and f_peri showed the best diagnostic performance.

CONCLUSION

IVIM model demonstrated capability to differentiate cervical cancer, where the derived F value may be a significant parameter for the grading of cervical cancer, according to tumor angiogenesis.

REFERENCE

[1] Lee EYP, Yu X, Chu MMY, et al. Perfusion and diffusion characteristics of cervical cancer based on intraxovel incoherent motion MR imaging-a pilot study. Eur Radiol. 2014 Jul;24(7):1506-13.

[2] Singh N, Arif S. Histopathologic parameters of prognosis in cervical cancer- a review. Int J Gynecol Cancer. 2004;14(5):741–50.