An exploratory pilot study into the correlation of MRI perfusion, diffusion parameters and 18F-FDG PET metabolic parameters in primary head and neck cancer

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PURPOSE: Microcirculation, cellularity and glucose metabolism may have relationship or affect each other in the same tumor. The understanding of their relationship could contribute to the field of oncologic imaging such as tumor characterization, guidance for treatment planning, early prediction of treatment responses and evaluation of treatment outcome.[1] In this study, we investigated the relationships between tumor metabolism determined by ^{18}FDG positron emission tomography, tumor microcirculation determined by dynamic contrast enhanced MRI, and tumor cellularity determined by diffusion MRI in patients with primary head and neck cancer.

METHODS: We included 14 patients (13 men, 1 women; mean age, 62.64 years ± 13.79 [SD]) with histopathologically proven head and neck cancer, who underwent DCE-MRI, DWI (b values; 0 and 1000 seconds/mm^2) and ^{18}FDG PET before treatment. The mean time interval between MRI and ^{18}FDG PET/CT was 3.5 days (range: 0~14 days). The perfusion parameters (K_{trans}, K_{ep}, V_e, V_p, AUC) from DCE-MRI and apparent diffusion coefficient (Mean ADC [ADC_{mean}] and minimum ADC [ADC_{min}]) values from DWI were evaluated within the manually placed polygonal region of interest plotted around the main tumor on every image slice. Necrotic area and large feeding vessels are excluded from ROI. Maximum SUV (SUV_{max}) was measured for the entire tumor region of interest. Mean SUV (SUV_{mean}) and total lesion glycolysis (TLG = SUV_{mean} x tumor volume) were calculated with the margin thresholds as 40%. Data normality was tested by the Kolmogorov-Smirnov test. Comparisons were made by using Pearson correlation.

RESULTS: Averaged values of DCE-MRI, DWI and ^{18}FDG PET parametersare summarized in Table 1. Significant correlations were shown between K_{trans} and TLG (r=0.609), V_e and TLG (r=0.575), AUC and TLG (r=0.635), ADC_{min} and TLG (r=-0.604), and ADC_{mean} and V_p (r=0.541) (Table 2, Fig 1). A representative case of DCE-MRI, DWI and PET-CT imaging is shown in Fig 2.

DISCUSSION: K_{trans} represents the leakiness of incompetent vessel which newly formed by tumor angiogenesis. AUC is a measure of the amount of contrast delivered to and retained within the tumor within the stated time period. These parameters reflect availability and delivery of blood in the tumor tissue, that is, tumor perfusion. Glucose consumption of tumor tissue is affected by tissue perfusion; therefore we can explain the correlation of DCE parameters with TLG from FDG-PET.[2] Glycolytic activity of tumor is influenced by cellularity, growth rate and viable tumor volume. ADC, measured by DWI, inversely correlated with tumor cellularity. Negative correlation between ADC and tumor glycolysis have been approved.[3-4] V_e means extracellular volume per unit volume of tissue and represents cell density.[5] We estimated that high tumor glycolysis reflect the high cellularity and will be negatively correlated with V_e. However, actually V_e showed positive correlation with TLG. This may be explained by the fact that V_e is calculated as “unrealistically” high value because of the abnormal, chaotic architecture of the tumor tissue including micronecrosis.[2]

CONCLUSION: This study demonstrated the correlation between tumor microcirculation, celluarity and glucose metabolism using DCE-MRI, DWI and FDG-PET which based on different mechanism. This relationship is complex and each diagnostic technique may provide complementary information for the tumor biology.

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Table 1. The averaged values of DCE-MRI, DWI and ^{18}FDG PET parameters in the tumor sites

Quantitative parameters	Averaged value
K_{trans} (min^{-1})	1.26 ± 0.63
K_{ep} (min^{-1})	3.59 ± 1.25
V_e	0.45 ± 0.25
V_p	0.12 ± 0.03
AUC	0.39 ± 0.15
ADC_{mean} (x10^{-3}mm^2/s)	0.88 ± 0.18
ADC_{min} (x10^{-3}mm^2/s)	0.31 ± 0.20
SUV_{max}	12.18 ± 3.74
SUV_{mean}	6.72 ± 1.29
TLG (g)	124.5 ± 126.7

Data are expressed as mean ± standard deviation

Table 2. Correlation analysis of the DCE-MRI, DWI and ^{18}FDG PET parameters in the tumor sites

	ADC_{mean}	ADC_{min}	SUV_{max}	SUV_{mean}	TLG
K_{trans}	0.026/ 0.93	-0.284/ 0.32	0.021/ 0.94	0.213/ 0.46	**0.609/ 0.02***
K_{ep}	0.174/ 0.55	0.063/ 0.83	-0.031/ 0.91	-0.074/ 0.80	-0.182/ 0.53
V_e	-0.128/0.66	-0.296/0.30	0.055/ 0.85	0.231/ 0.42	**0.575/ 0.03***
V_p	**0.541/ 0.046***	-0.268/ 0.355	-0.172/ 0.55	-0.014/ 0.96	0.185/ 0.52
AUC	0.024/ 0.93	-0.327/ 0.25	-0.030/ 0.91	0.188/ 0.51	**0.635/ 0.01***
ADC_{mean}			-0.362/ 0.20	-0.281/ 0.33	-0.371/ 0.19
ADC_{min}			-0.263/ 0.36	-0.371/ 0.19	**-0.604/ 0.02***

Data are expressed as correlation coefficient(Pearson r)/p-value
The statistically significant correlations are indicated with an asterisk

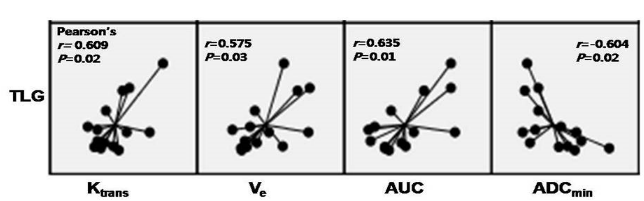

Fig 1. Scatterplots showing correlations between parameters