Parotid sparing volume-dependent perfusion characteristics of acute radiation injury: investigated by fat-saturated dynamic contrast-enhanced MRI

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Introduction
The highly radiosensitive parotid glands could be protected by using parotid sparing techniques such as 3D-conformal radiotherapy (3DCRT) or intensity modulated radiotherapy (IMRT). A prior study has shown that dynamic contrast-enhanced (DCE) MRI allows quantitative measurements of parotid perfusion characteristics in late radiation injury at a mean radiation dose of 36 Gy [1]. To the best of our knowledge, the parotid perfusion characteristics in acute radiation injury in patients receiving parotid-sparing radiotherapy have never been documented yet. In this study, we aimed to evaluate the parotid perfusion characteristics in acute radiation injury and to quantify the relationship between the parotid-sparing volume (PSV) and perfusion alterations.

Material and Method

Subject
Fifteen patients (11 male and 4 female) were included in this study. They were pathologically proven as nasopharyngeal carcinoma (NPC) and received MR studies before and within 3 months after radiotherapy (RT). The age of patients was 49.1 ± 14.2 years. The RT dose was delivered to parotid glands at 27.47 ± 3.96 Gy, using intensity modulated RT (IMRT) technique. PSV, which was defined as the percentage volume of parotid gland with exposed radiation dose less than 25 Gy, was calculated by a radiation oncologist.

Image acquisition
All MRI examinations were performed on a 1.5T clinical system (GE Healthcare, Signa HDx, USA). A fast spin-echo sequence was adopted, and fat saturation was utilized for a better differentiation from the parotid gland and the surrounding fatty tissue. TE and TR were set to be 12.63 and 400 ms respectively. The temporal resolution was 12.3 seconds, and 20 dynamics were acquired in total. Gd-DTPA was injected intravenously within 3 seconds with a dose of 0.1mmol/kg.

Data analysis
Here we took the 2-compartment Brix pharmacokinetic model to analyze the DCE data. Besides the parameters (A, k21, and kel) which were provided by the Brix model, other parameters including peak enhancement (PE), time-to-peak (TTP) and slope, were also calculated. PE is defined as the maximum value of the fit curve, TTP refers the time when the curve meets its maximum, and slope is defined as the ratio of PE/TTP. Normality of the perfusion parameters was examined using Q-Q plots and Kolmogorov-Smirnov tests. The perfusion parameters was examined using Q-Q plots and Kolmogorov-Smirnov tests. Pearson’s correlation test was adopted to evaluate the relationship of PSV and the perfusion parameters. A P value less than 0.05 was considered as statistically significant.

Result
As shown in Fig. 1, the result of the perfusion alteration exhibited significantly higher values in A, PE, TTP and slope, along with a significantly lower value in kel. Meanwhile in k21, an insignificant higher value was found. Fig. 2 showed significant correlations between perfusion parameters (A, k21, and slope) and PSV.

Discussion and conclusion
The higher values of PE, TTP and lower value of kel in our study are consistent with a previous study of irradiated parotid glands in acute stage [2]. Nevertheless, our results further demonstrate that the perfusion alterations are negatively associated with the PSV regarding the parameter A, k21, and slope. It also highlights that PSV plays an important role in differentiating the change of perfusion characteristics, especially when the changes is as subtle as in k21 and is not disclosed by using the paired t-test.

In conclusion, the perfusion alterations of the irradiated glands might be enhanced by taking PSV into consideration especially when the changes are subtle.

Reference