model. It was found that there was a significant correlation between the model and the immune microenvironment, especially model gene SPP1 and macrophages. Finally, we explored the difference of SPP1 pathway between adjacent tissues and tumor tissues, and found that SPP1 pathway played an important role in tumor tissues (Fig. 1). Therefore, the mechanism of SPP1 pathway in glioblastoma can be further explored.

5 - 69 Motion Management with Respiration Guidance Gating System Verified Firstly on the Heavy-ion Therapy Facility in Lanzhou

He Pengbo, Li Qiang, Li Guangru, Zhang Xinyang, Zhang Jun and Wang Jian

In order to treat the moving targets under the synchrotron-based pulsed heavy-ion beam delivery, a novel respiration guidance gating system (RG^2S) was developed to synchronize the patterns between the patients' respiration and synchrotron magnetic excitation curve (MEC)$^{[1-3]}$.

The respiratory synchronized irradiation was realized by adding a time interval between the adjacent MECs, which was calculated based on the even sequence of synchrotron and the period of a patient specific breathing guidance curve, as shown in Fig. 1(a). A short breath-hold time was added to the end exhalation phase that was coincident with the beam extraction flattop. In this way, each beam pulse can be fully utilized while the target is in a relative static state during irradiation.

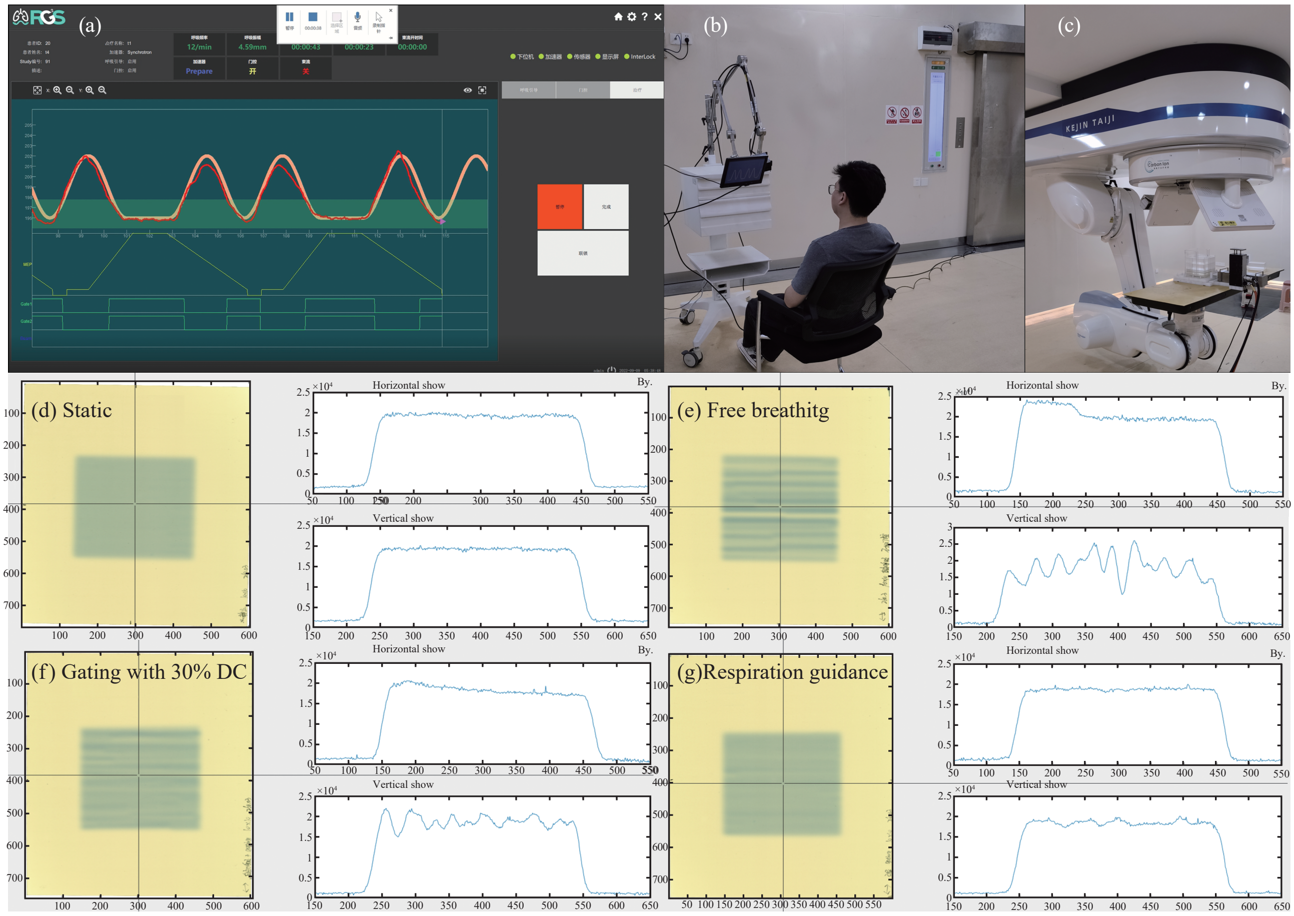

Fig. 1 (color online) (a) Synchronization between the volunteer's breathing and synchrotron magnetic excitation curve, (b) Volunteer breathing guidance test outside the treatment room, (c) Moving platform fixed in the treatment room. Measured dose distributions under, (d) Static situation, (e) Free breathing, (f) Gating with 30% duty cycle, (g) Respiration guidance.

The functionality and effectiveness of the RG^2S system were verified firstly on the Heavy Ion Medicine Machine (HIMM) in Lanzhou, China. A programmable portable moving platform was used to follow the volunteers' breath, where the volunteers conducted the breathing guidance tests outside the treatment room as shown in Fig. 1(b). It can be fixed in the treatment room (Fig. 1(c)). A treatment planning for a cubic target (6 cm × 6 cm × 6 cm, 2 Gy) was designed using raster scanning beam delivery mode with RayStation (RaySearch Laboratories AB, Stockholm, Sweden). As shown in Fig. 1(d∼g), the dose distribution uniformity was increased by a factor of 2.7 compared to the conventional gating method, while the treatment efficiency was increased 2.3 times. Thus, the RG^{2}S system greatly improved the performance of the heavy-ion treatment facility.

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5 - 70 Optimize the Breathing Phase Number in 4D Scanned Proton Optimization for Lung Tumors

Ma Yuanyuan, Liu Xinguo, Dai Zhongying, Zhang Hui, Li Yazhou and Li Qiang

Respiration-induced intra-fractional motion affects the actual radiation dose delivered to the tumor definitely, resulting in insufficient local control or severe damage to critical organs. To mitigate the impact of intra-fractional motion, many approaches such as respiratory gating, tumor tracking, breath hold and motion-encompassing methods have been proposed. Besides, incorporating the motion into treatment planning optimization is another attractive alternative, in which the treatment plan is optimized based on time-resolved computed tomography (CT) data sets. The standard four-dimensional (4D) treatment planning includes all breathing states in the optimization process, which is time-consuming and strenuous. This work was aimed to optimize the number of intermediate phases needed for four-dimensional (4D) proton plan optimizations so as to reduce the computational cost and improve the efficiency of the planning process.

Five planning strategies were studied for fifteen lung cancer patients treated with scanned protons. Different number of breathing phases as follows were adopted in the optimization process: a) all ten phases (4D_10), b) two extreme phases (4D_2), c) six phases during the exhalation stage (4D_6EX), d) six phases during the inhalation stage (4D_6IN), and e) two extreme phases plus an intermediate state (4D_3). The 4D dose evaluation was conducted on all ten phases, considering the interplay effect between the dynamic beamlet delivery and respiratory motion. The resulting doses accumulated on the reference phase were estimated and compared.

In this cohort, no obvious relationship between the tumor size and motion amplitude and the performance of the four restricted strategies was observed (Fig. 1). Take the tumor of 1.04 mm / 40.82 cc (the motion amplitude was smaller than 5 mm) as an example, the conformity index (CI) values calculated from 4D_2, 4D_3, 4D_6EX and 4D_6IN approaches were clearly different from the result of the 4D_10 plan. As for and the target heterogeneity index (HI) and D98 values, the 4D optimization plans adopting limited phase number performed similar to the 4D_10 plan with the tumor amplitude smaller than 5 mm.

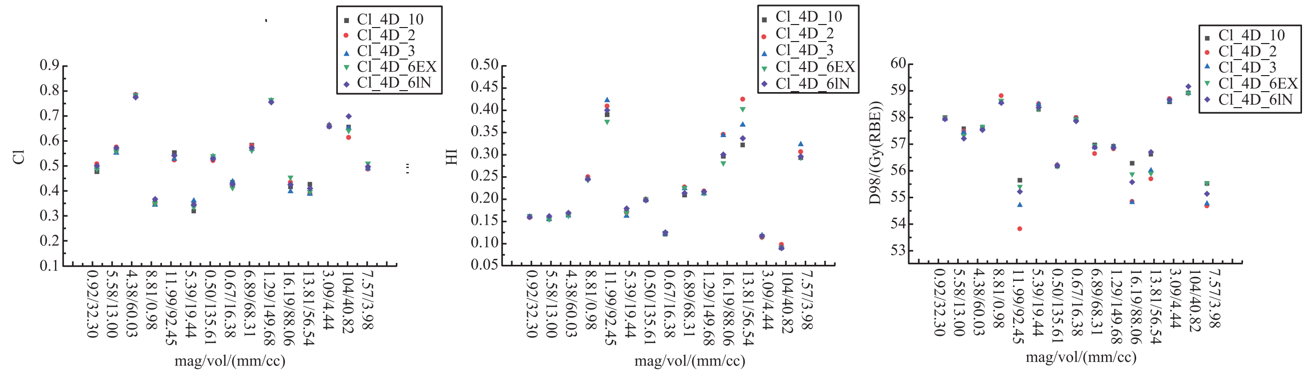

Fig. 1 (color online) The average CI, HI and D98 values calculated from all the plans for each patient. The horizontal axis represents the motion amplitude and volume of the 15 patients.