Cone-beam computed tomography (CBCT)-guided small animal radiation research platform (SARRP) has provided unique opportunities to test radiobiological hypotheses. However, CBCT is less adept to localize soft tissue targets growing in a low imaging contrast environment. Three-dimensional bioluminescence tomography (BLT) provides strong image contrast and thus offers an attractive solution. Deng et al. introduced a novel and efficient BLT-guided conformal radiation therapy and demonstrated it in an orthotopic glioblastoma (GBM) model.

A multispectral BLT system was integrated with SARRP for radiation therapy (RT) guidance. GBM growth curve was first established by contrast-CBCT/MRI to derive equivalent sphere as approximated gross target volume (aGTV). For BLT, mice were subject to multispectral bioluminescence imaging, followed by SARRP CBCT imaging and optical reconstruction. The CBCT image was acquired to generate anatomical mesh for the reconstruction and RT planning. To ensure high accuracy of the BLT-reconstructed center of mass (CoM) for target localization, they optimized the optical absorption coefficients μa by minimizing the distance between the CoMs of BLT reconstruction and contrast-CBCT/MRI-delineated GBM volume. The aGTV combined with the uncertainties of BLT CoM localization and target volume determination was used to generate estimated target volume (ETV). For conformal irradiation procedure, the GBM was first localized by the pre-determined ETV centered at BLT-reconstructed CoM, followed by SARRP radiation. The irradiation accuracy was qualitatively confirmed by pathological staining.

Deviation between CoMs of BLT reconstruction and contrast-CBCT/MRI-imaged GBM is approximately 1.0 mm. The derived ETV centered at BLT-reconstructed CoM covers > 95% of the tumor volume. Using the 2nd-week GBM as an example, the ETV-based BLT-guided irradiation can cover 95.4 ± 4.7% tumor volume at prescribed dose. The pathological staining demonstrated the BLT-guided irradiated area overlapped well with the GBM location.

The BLT-guided RT enables 3D conformal radiation for important orthotopic tumor models, which provides investigators a new pre-clinical research capability [1)].

1)
Deng Z, Xu X, Garzon-Muvdi T, Xia Y, Kim E, Belcaid Z, Luksik A, Maxwell R, Choi J, Wang H, Yu J, Iordachita I, Lim M, Wong JW, Kang-Hsin Wang K. In vivo Bioluminescence Tomography Center of Mass-Guided Conformal Irradiation. Int J Radiat Oncol Biol Phys. 2019 Nov 15. pii: S0360-3016(19)34001-5. doi: 10.1016/j.ijrobp.2019.11.003. [Epub ahead of print] PubMed PMID: 31738948.