Ionizing radiation

It is elusive whether clonal selection of tumor cells in response to ionizing radiation (IR) is a deterministic or stochastic process. With high resolution clonal barcoding and tracking of over 400.000 HNSCC patient-derived tumor cells the clonal dynamics of tumor cells in response to IR was analyzed. Fractionated IR induced a strong selective pressure for clonal reduction which significantly exceeded uniform clonal survival probabilities indicative for a strong clone-to-clone difference within tumor cell lines. IR induced clonal reduction affected the majority of tumor cells ranging between 96-75% and correlated to the degree of radiation sensitivity. Survival to IR is driven by a deterministic clonal selection of a smaller population which commonly survives radiation, while increased clonogenic capacity is a result of clonal competition of cells which have been selected stochastically. A 2-fold increase in radiation resistance results in a 4-fold ($p<0.05$) higher deterministic clonal selection showing that the ratio of these parameters is amenable to radiation sensitivity which correlates to prognostic biomarkers of HNSCC. Evidence for the existence of a rare subpopulation with an intrinsically radiation resistant phenotype commonly surviving IR was found at a frequency of 0.6-3.3% ($p<0.001$, FDR 3%). With cellular barcoding we introduce a novel functional heterogeneity associated qualitative readout for tracking dynamics of clonogenic survival in response to radiation. This enables the quantification of intrinsically radiation resistant tumor cells from patient samples and reveals the contribution of stochastic and deterministic clonal selection processes in response to IR [1)].

Ionizing radiation is typically used during spine surgery for localization and guidance in instrumentation placement.

Minimally invasive (MI) surgical procedures are increasingly popular often require significantly more fluoroscopy, placing surgeons at risk for increased radiation exposure and radiation-induced complications.

PubMed database was queried for relevant articles pertaining to radiation exposure in spine surgery.

Discectomy, Percutaneous Pedicle screw fixation, MI transforaminal lumbar interbody fusion (TLIF), MI lateral lumbar interbody fusion, and vertebroplasty/kyphoplasty procedures were assessed. The highest radiation doses were seen with MI pedicle screw placement, MI TLIF, vertebroplasty/kyphoplasty, and percutaneous endoscopic lumbar discectomy. Use of lead aprons and thyroid shields reduces effective dose by several orders of magnitude. Proper operator positioning also minimizes radiation exposure. Lead gloves decrease dose to the surgeon's hand from scatter if the hand is out of the x-ray beam the majority of the time. If prolonged exposure of the hand cannot be avoided, the technician should collimate the surgeon's hand out of the beam or use instruments to position the hand farther from the beam. In addition to using less fluoroscopy, pulsed fluoroscopy can also decrease overall dose in a procedure.

Spine surgeons should reduce radiation exposure to minimize risk of potential long-term complications. Strategies include minimizing fluoroscopy use and dose, proper use of protective gear, and appropriate manipulation of fluoroscopic equipment [2)].

Magnetic resonance imaging represents a imaging technique that does not use ionizing radiation.

1)

Wursthorn A, Schwager C, Kurth I, Peitzsch C, Herold-Mende C, Debus J, Abdollahi A, Nowrouzi A. High complexity cellular barcoding and clonal tracing reveals stochastic and deterministic parameters of radiation resistance. Int J Cancer. 2021 Oct 27. doi: 10.1002/ijc.33855. Epub ahead of print. PMID: 34706068.

2)

Srinivasan D, Than KD, Wang AC, La Marca F, Wang PI, Schermerhorn TC, Park P. Radiation Safety and Spine Surgery: Systematic Review of Exposure Limits and Methods to Minimize Radiation Exposure. World Neurosurg. 2014 Jul 31. pii: S1878-8750(14)00701-3. doi: 10.1016/j.wneu.2014.07.041. [Epub ahead of print] Review. PubMed PMID: 25088230.