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Ionizing radiation inhibits hatching of zebrafish embryo by inducing tissue inhibitors of metalloproteinases in transcriptional level

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Ionizing radiation (IR) has gained increasing attention for the reason of biological effects on the aquatic organism as well as human being. IR affects brain development in vertebrates at early developmental stages, but its effects of IR on other developing tissues have not yet been clarified. To investigate the IR effects on the developing organs, single-cell RNA sequencing was conducted using zebrafish embryos. The single-cell RNA sequencing revealed that the proportion of brain or central nervous system and hatching gland were notable changed. We emphasized the effects of IR on the hatching gland because delayed hatching and increased hatching gland cell numbers were observed. A Gene Ontology analysis was conducted on differentially expressed genes in the hatching gland to investigate the delay in hatching following IR exposure. The expression of tissue inhibitors of metalloproteinases (TIMPs), which inhibit the activity of matrix metalloproteinases, were increased and validated by performing whole mount in situ hybridization (WISH). To investigate the reasons for the increase of TIMPs, correlation analysis was performed. Consequently, cebpb, cebpd, and TIMPs were found to be significantly correlated after IR exposure. This is the first study to observe toxicity caused by IR exposure at the single-cell level.