3D Visualization of Developmental Toxicity of -2,4,6-Trinitrotoluene in Zebrafish Embryogenesis Using Light Sheet Microscopy

Juneyong Eum, Jina Kwak, Hee Joung Kim, Seoyoung Ki, Kooyeon Lee, Ahmed A. Raslan, Ok Kyu Park, Md Ashraf Uddin Chowdhury, Song Her, Yun Kee, Seung-Hae Kwon and Byung Joon Hwang

Abstract:

Environmental contamination by trinitrotoluene is of global concern due to its widespread use in military ordnance and commercial explosives. Despite known long-term persistence in groundwater and soil, the toxicological profile of trinitrotoluene and other explosive wastes have not been systematically measured using in vivo biological assays. Zebrafish embryos are ideal model vertebrates for high-throughput toxicity screening and live in vivo imaging due to their small size and transparency during embryogenesis. Here, we used Single Plane Illumination Microscopy (SPIM)/light sheet microscopy to assess the developmental toxicity of explosive-contaminated water in zebrafish embryos and report 2,4,6-trinitrotoluene-associated developmental abnormalities, including defects in heart formation and circulation, in 3D. Levels of apoptotic cell death were higher in the actively developing tissues of trinitrotoluene-treated embryos than controls. Live 3D imaging of heart tube development at cellular resolution by light-sheet microscopy revealed trinitrotoluene-associated cardiac toxicity, including hypoplastic heart chamber formation and cardiac looping defects, while the real time PCR (polymerase chain reaction) quantitatively measured the molecular changes in the heart and blood development supporting the developmental defects at the molecular level. Identification of cellular toxicity in zebrafish using the state-of-the-art 3D imaging system could form the basis of a sensitive biosensor for environmental contaminants and be further valued by combining it with molecular analysis.

Keywords:

3D live imaging; cardiac defect; fetal defect; light-sheet microscopy; pink water; single plane illumination microscopy; trinitrotoluene; zebrafish embryos

Published In:

International Journal of Molecular Sciences , 17 , NULL