UNIVERSA MEDICINA

pISSN: 1907-3062 / eISSN: 2407-2230

Univ Med 2024;43:1-3

DOI: http://dx.doi.org/10.18051/UnivMed.2024.v43:1-3

INVITED EDITORIAL

Embryology and developmental toxicity risk assessment: complexity, concerns, and implications for industrializing developing nations

Osaretin G. Igharo

Department of Medical Laboratory Science, School of Basic Medical Sciences, College of Medical Sciences, University of Benin, Benin City, Edo State, Nigeria

osaretin.igharo@uniben.edu

Date of first submission, January 2, 2024
Date of final revised submission, January 21, 2024
Date of acceptance, January 29, 2024

INTRODUCTION

Embryology is the branch of biology that deals with the study of embryonic development, the process by which an organism develops from a single cell (fertilized egg) to a multicellular organism.[1] It encompasses the changes that occur from fertilization to the formation of a fully developed organism. The study of embryology helps us to understand the developmental process that leads to the formation of the different body systems and organs, as well as how genetic and environmental factors can affect this process.[2] Embryonic development is a complex and dynamic process that involves the coordinated interaction of various genetic and environmental factors.[3] During the embryonic period, the fertilized egg undergoes a series of critical developmental events, including cell division, differentiation, and migration, which lead to the formation of various tissues and organs.[1] These events are regulated by a complex network of genetic and biochemical processes, and any disruption to these processes can result in developmental abnormalities or birth defects.[2] Embryology has important practical applications in medicine, as a better understanding of embryonic development can provide insights into the causes of birth defects, infertility, and other developmental disorders.[3] Additionally, it can inform on the development of new treatments and technologies for these conditions.[1]

Developmental toxicity testing is a crucial step in the evaluation of the safety of chemicals, pharmaceuticals, and other substances. The aim of this testing is to identify any potential adverse effects on the developing fetus during pregnancy. The goal of developmental toxicity testing is to determine whether a substance can cause harm to the developing fetus, including birth defects, growth retardation, or functional deficits.[4] Developmental toxicity testing is usually performed using animal models, where the substance is administered to pregnant animals and the offspring are evaluated for any adverse effects. The results from these studies are then used to predict the potential risks to human fetuses and to inform regulatory decisions about the use of the substance.[5,6]

Toxicity is the degree to which a chemical substance or a particular mixture of substances can damage an organism.[7] Developmental toxicity testing is primarily used to determine hazards regarding the potential effects of prenatal exposure on the developing fetus.[8] The most important developmental phase is the organogenesis period that is always taken into account in developmental toxicity testing.

Chemical compounds can be categorized as teratogenic by recording structural malformations, developmental retardation and/or mortality, respectively. The vast majority of teratogenic chemical agents have been identified using rodent experimental models. However, the failure of rodents to detect teratogenic signals on some occasions and the similarities in placentation and physiology of pregnancy between humans and rabbits have led to the use of the rabbit as a second model for assessing the effects of toxic compounds on development.[8] Furthermore, although non-human primates have been suggested as models for teratological testing, they have several limitations such as a long gestation period, only single or twin offspring, high rates of abortion, and ethical constraints.[9]

The complexity and implications of developmental toxicity have constituted significant concerns to regulatory agencies such as the United States Environmental Protection Agency (EPA), the United States Food and Drug Administration (FDA), Food and Agriculture Organization (FAO) of the United Nations, World Health Organization (WHO), the Occupational Safety and Health Administration (OSHA), amongst others. In line with these concerns, a number of technological methods as well as guidelines have been developed for assessing the risks of developmental toxicity from exposure to environmental agents.[10] The four major manifestations of developmental toxicity are death, structural abnormality, altered growth, and functional deficit. The relationship among these manifestations may vary with increasing dose and, especially at higher doses, death of the conceptus may preclude expression of other manifestations.

Growing evidence indicates that chemical utilization including toxic waste in the developing countries is on the increase.[11] These nations have limited facilities for sound chemical management involving production, use, and disposal of chemicals with minimal adverse effects on human and environmental health. Though concerns are important to all nations, they appear particularly salient to the industrializing countries under pressures to achieve development and eradicate poverty yet with limited capacity for sound chemical management. This increases the risk of chemical toxicity, with consequences such as genotoxicity, cancer, and teratogenicity.[12] It is possible to address the inadequate technological advances in science and medicine to drive diagnosis and technological intervention in developmental toxicity risk assessment to resolve its complexity and concerns, as well as to mitigate the adverse implications that may be associated with industrializing developing nations in this regards. The integration of various testing methods enhances our understanding of developmental toxicity and helps regulators and scientists make informed decisions regarding substance safety. Although these may be very challenging in developing and industrializing nations where the risks are apparently higher, there are fewer prospects for intervention and mitigation, hence the need to develop a workable framework for integrated intervention.

REFERENCES

1. Khan YS, Ackerman KM. Embryology, week 1. (updated 2023 Apr 17). Treasure Island (FL): StatPearls Publishing; 2023.
2. Singh V. Textbook of clinical embryology, 3rd ed. -E-Book. New Delhi: Elsevier Health Sciences;2022.
3. Wickramasekara RN, Stessman HAF. Histone 4 lysine 20 methylation: a case for neurodevelopmental disease. Biology (Basel) 2019; 8:11. doi: 10.3390/biology8010011.
4. Sachana M, Hargreaves AJ. Toxicological testing: in vivo and in vitro models. In: Gupta RC, editor. Veterinary toxicology: basic and clinical principles. 3rd ed. London: Academic Press/ Elsevier; 2018. p.145-161. DOI: https://doi.org/10.1016/ C2016-0-01687-X.
5. DeSesso JM. Future of developmental toxicity testing. Current Opinion in Toxicology 2017; 3:1–5. https://doi.org/10.1016/j.cotox.2017.04.001.
6. Conde-Agudelo A, Romero R. Prediction of preterm birth in twin gestations using biophysical and biochemical tests. Am J Obstet Gynecol 2014; 211:583-95. doi: 10.1016/j.ajog.2014.07.047.
7. McCarty LS, Borgert CJ, Burgoon LD. Evaluation of the inherent toxicity concept in environmental toxicology and risk assessment. Environ Toxicol Chem 2020;39:2351-60. doi: 10.1002/etc.4881.
8. Ciallella HL, Russo DP, Sharma S, et al. Predicting prenatal developmental toxicity based on the combination of chemical structures and biological data. Environ Sci Technol 2022; 56:5984-98. doi: 10.1021/acs.est.2c01040.
9. Fraga LR, Vianna FSL, Del Campo M, Sanseverino MTV, Schuler-Faccini L. Editorial: teratogenesis: experimental models, mechanisms and clinical findings in humans. Front Genet 2022; 13:901400. doi: 10.3389/fgene.2022. 901400.

10. National Research Council (US) Committee on Risk Assessment of Hazardous Air Pollutants. Science and judgment in risk assessment. Washington (DC): National Academies Press (US); 1994.
11. Rousseaux CG, Bolon B. Embryo, fetus, and placenta. In: Wallig MA, Bolon B, Haschek WM, Rousseaux CG, editors. Fundamentals of toxicologic pathology.3rd ed. London: Academic Press; 2017. p. 823-53.
12. Igharo OG, Anetor JI, Anetor GO, Nwobi LN, Osagie OA, Osunbor JO. Toxicant-nutrient interaction as a veritable host resistance against chemical toxicity in the rapidly industrializing developing nations. Trop J Nat Prod Res 2017; 1: 196-8. doi.org/10.26538/tjnpr/v1i5.4.