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STATE-OF-THE-ART REVIEW

Effects of Environmental Exposures on Fetal and Childhood Growth Trajectories

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Abstract

Delayed fetal growth and adverse birth outcomes are some of the greatest public health threats to this generation of children worldwide because these conditions are major determinants of mortality, morbidity, and disability in infancy and childhood and are also associated with diseases in adult life. A number of studies have investigated the impacts of a range of environmental conditions during pregnancy (including air pollution, endocrine disruptors, persistent organic pollutants, heavy metals) on fetal and child development. The results, while provocative, have been largely inconsistent. This review summarizes up to date epidemiologic studies linking major environmental pollutants to fetal and child development and suggested future directions for further investigation.

KEY WORDS prenatal exposure, environmental pollutants, fetal growths, adverse birth outcomes, low birth weight, catch-up growth, child development

INTRODUCTION

Impaired fetal growth represents one of the greatest public health threats to this generation of children. More than 30 million low-birth-weight (LBW; <2500 g) infants are born annually worldwide. It is now widely accepted that altered fetal growth, LBW, and rapid growth in early childhood (catch-up growth) are associated with an increased risk for multiple diseases in adulthood, including hypertension, obesity, cardiovascular diseases, diabetes, and cancers. Thus, identification of the risk factors for impaired fetal growth, LBW, and catch-up growth will help to not only improve children's health but also to provide etiologic insight and inform prevention strategies for many adult diseases. Although tremendous efforts have been made to understand these risk factors, results from epidemiologic studies have been inconsistent, and the environmental factors that may induce this human suboptimal fetal growth and rapid catch-up growth are currently unclear.

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EFFECTS OF ENVIRONMENTAL EXPOSURES ON FETAL AND CHILDHOOD GROWTH

A better understanding of the potential effects of environmental exposures on fetal and childhood growth is of marked public health significance because of increasing exposure levels of a variety of pollutants resulting from increased industrialization; the known capability of environmental pollutants to readily transport across the placenta; plausible mechanisms linking environmental exposures to impaired fetal and childhood growth; and the influence of early-life exposures on the risk for both childhood and adult diseases. In this review, we provide a brief but thorough overview of the studies linking 4 major environmental pollutants (perfluorinated compounds [PFCs], heavy metals, polyhalogenated aromatic hydrocarbons [PHAHs], and air pollutants) to perturbations in fetal and childhood growth and development.

Effects of Prenatal Exposure to Perfluorinated Compounds on Fetal and Childhood Growth.

Definition

PFCs, also known as perfluorinated alkylated substances (PFAS), are a class of man-made organofluorine compounds. Fluorocarbons are both lipophobic and hydrophobic. The 2 most extensively used and studied PFCs are perfluorooctanoic acid (PFOA) and perfluorooctanesulfonic acid (PFOS), each of which have an 8-carbon backbone and are hence also known as C8. Because of their strong C-F covalent bonds, PFOA/PFOS are resistant to degradation processes, which allow them to persist indefinitely in the environment as some of the most widespread persistent emerging environmental contaminants.[1,2]

Exposure

Humans are exposed to PFCs on a daily basis through intake of contaminated food, water, air, and dermal exposure due to widespread use in consumer and industrial products since the 1950s as surfactants and emulsifiers.[1,3,4] Their unique water- and oil-repelling characteristics make them suitable for diverse applications in manufacturing of food packaging and containers (eg, microwave popcorn bags), nonstick cookware, textiles, carpet and carpet cleaning liquids, upholstered furniture, cosmetics, household cleaners, refrigerants, adhesives, construction materials, electronic and photographic devices, fire retardants, and insecticides. During the past decade, efforts have been made to eliminate these persistent chemicals from the US market. As such, PFOA production has been reduced and PFOS is no longer manufactured in the United States. However, because of their widespread presence in the environment, their resistance to degradation, their ability to bioaccumulate in humans, and their wide production and use in developing countries (eg, PFOS production alone reached >250 tons a year in China in 2006),[5] these pollutants have been detected worldwide in the environment, wildlife, and humans. In the US general population, PFOA/PFOS can be detected in almost all serum samples. These compounds are stored in the blood with high affinity for albumin or liver and kidney,[6] can cross the placental barrier reaching the fetal circulation, and pass to infants through breastfeeding.

Epidemiologic Studies and Potential Mechanisms of PFC Exposure, Fetal Development, and Birth Size

Despite the fact that PFCs have been extensively used in industrial and consumer products since the 1950s and exposure to PFCs has been clearly demonstrated to result in developmental toxicity in animal studies,[7-10] their potential adverse effect on human health threat, especially the association of prenatal exposure and fetal growth, has only recently received much attention. Our knowledge of PFC-induced developmental effects in humans is still in its infancy.[11] We are not aware of any published studies to date that have directly investigated the relationship between prenatal exposure to PFCs and fetal growth based on ultrasound measures of fetal development. Instead, previous studies have used birth size as a marker for fetal growth and development and several epidemiologic studies have reported an association between maternal serum or cord blood PFOA/PFOS concentrations and lower birth weight,[12-20] with some of them reporting a statistically significantly reduced birth weight associated with exposure to PFOA[12,13,15,18,21] and/or PFOS (Table 1).[16,19,21] Two studies also reported a significant inverse association with birth weight for maternal exposure to perfluorohexane sulfonate (PFHxS).[11,21] Exposure to both PFOA and PFOS[12] or PFOS alone[11] was also associated with a significant inverse association with ponderal index. Several studies, however, found no association between prenatal exposure to PFCs and birth weight, birth length, or ponderal index.[15,20,22-25]