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Bisphenol A Data in NHANES Suggest Longer Than Expected Half-Life, Substantial Non-Food Exposure, or Both

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Abbreviations:

ANOVA = analysis of variance

BMI = body mass index

BPA = bisphenol A

CDC = Centers for Disease Control and Prevention

CI = confidence interval

K_{ow} = octanol-water partition coefficient

LOD = limit of detection

NHANES = National Health and Nutrition Examination Survey

OR = odds ratio

PIR = poverty income ratio

PK = pharmacokinetic

Pop $\frac{1}{2}$ = population-based half-life

PVC = polyvinyl chloride

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Abstract

Background: It is commonly stated in the human bisphenol A (BPA) literature that food is the predominant BPA exposure source, and that BPA is rapidly and completely cleared from the body. If correct, BPA levels in fasting individuals should decrease with increased fasting time.

Objectives: To investigate the relationship between urine BPA concentration and fasting time in a population-based sample.

Methods: We modeled log BPA urine concentration as a function of fasting time, adjusted for urine creatinine and other confounders, in 1469 adult participants in the 2003-2004 National Health and Nutrition Examination Survey. We estimated the BPA “population-based half-life” (pop $\frac{1}{2}$) for a fasting time of 0-24 hours, <4.5 hours, 4.5-8.5 hours and >8.5 hours.

Results: The overall pop $\frac{1}{2}$ for the 0-24 hr interval was 43 hrs (95% CI 26-119 hrs). Among those reporting fasting times of 4.5-8.5 hrs (n = 441), BPA declined significantly with fasting time, with a pop $\frac{1}{2}$ of 4.1 hrs (95% CI 2.6-10.6 hrs). However, within the fasting time intervals of 0-4.5 hrs (n = 129) and 8.5-24 hrs (n = 899), we saw no appreciable decline. Fasting time did not significantly predict highest (> 12 ng/ml) or lowest (below limit of detection) BPA levels.

Conclusions: Overall, BPA levels did not decline rapidly with fasting time in this sample. This suggests substantial non-food exposure, accumulation in body tissues such as fat, or both. Explaining these findings may require experimental pharmacokinetic studies of chronic BPA exposure, further examination of BPA levels and effects in fat, and a search for important non-food sources.

Introduction

Bisphenol A (BPA) is a high volume industrial chemical that is polymerized to form polycarbonate plastics and epoxy resins, and is a constituent of polyvinyl chloride (PVC) plastic. These materials are used to line metal food and drink containers, as dental sealants, and for manufacturing PVC pipe and polycarbonate drink containers. The ester bonds that enable the polymerization of BPA can be broken, particularly under exposure to heat, releasing free BPA (Kang et al. 2006).

BPA has long been described as a weak estrogen due to its low affinity for nuclear estrogen receptors, but recent studies have shown BPA equipotent with estradiol in its ability to initiate rapid nongenomic responses from membrane surface receptors (Quesada et al. 2002; Wozniak et al. 2005). Whether BPA can cause human health effects is a matter of some debate; the potential for harm to infants and the fetus is currently considered more likely than harm to adults (NTP 2008; vom Saal et al. 2007).

The Centers for Disease Control and Prevention (CDC) estimates that 93% of Americans aged 6-85+ have detectable urine levels of BPA (parent BPA and conjugated metabolites), based on 2003-2004 data from NHANES, the National Health and Nutrition Examination Survey (Calafat et al. 2008b). The median BPA for all ages was 2.7 ng/ml, with the lowest levels found in males, Mexican Americans, and subjects with higher income.

Exposure is thought to be almost exclusively from food (NTP 2008). For example, Wilson et al. (2007) examined exposure to BPA and other phenols in 275 young children ages 1.5-5 years. They concluded that 99% of BPA exposure was dietary based on measurements of BPA levels from a variety of sources such as food, air, and house dust. Since their preliminary survey did not find BPA in tap water, it was not subsequently measured in the main study (Nancy Wilson, personal