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Blood pressure in relation to contamination by polychlorobiphenyls and organochlorine pesticides: Results from a population-based study in the Canary Islands (Spain)

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ABSTRACT

Background: Epidemiological studies have reported significant associations between exposure to persistent organic pollutants (POPs) and increased blood pressure (BP). Environmental exposure to POPs, mainly organochlorine pesticides, is of concern to the population of the Canary Islands, who display a high prevalence of diseases associated with hypertension such as metabolic syndrome, obesity and cardiovascular disease.

Objective: We performed this population-based study in a representative population sample from this archipelago to evaluate whether serum levels of selected POPs could be considered as hypertension risk factors.

Methods: BP and several other well-known factors related to hypertension (gender, age, smoking, BMI, and total lipids) were recorded in 428 adult participants from the Canary Islands Nutritional Survey. In total, 28 POPs (including 18 polychlorinated biphenyl (PCB) congeners and 10 organochlorine pesticides and metabolites) were measured in the serum of the population enrolled in this survey.

Results: In total, 167 subjects (39%) demonstrated hypertension or used antihypertensive medication. We observed a positive association between systolic and diastolic BP and *p,p′*-DDE ($r=0.222$; $p<0.001$, and $r=0.123$; $p=0.015$, respectively). Conversely, an inverse association between systolic BP and aldrin was observed ($r=-0.120$; $p=0.017$). After adjusting for known confounders, only aldrin was inversely related to hypertension risk [OR: 0.28 (95% CI: 0.09–0.92); $p=0.037$]. After excluding subjects undergoing antihypertensive treatment, we also observed that aldrin was inversely associated with systolic BP in multivariate analyses, especially in men [OR: 0.126 (95% CI: 0.021–0.763); $p=0.024$].

Conclusion: Although it has been postulated that background POPs exposure may play a relevant role on elevated BP, we did not observed increased hypertension risk in relation to serum POPs in this cross-sectional study. Conversely, the cyclodiene pesticide aldrin was negatively associated with hypertension, suggesting that cyclodienes could exert an effect opposite of the DDT metabolites. These findings agree with other previous works indicating that POPs may induce divergent actions on BP and suggest that the direction of the association between BP and POPs could be dependent on the chemical structure as well as concentration of the evaluated POP. Prospective studies are needed to clarify the effect exerted by POPs on BP.

1. Introduction

Exposure to environmental contaminants such as organochlorine pesticides (OCPs) and polychlorobyphenyls (PCBs), is a concern in most populations worldwide. These chemicals (and other halogenated contaminants) are considered as persistent organic

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pollutants (POPs), because they are resistant to biotic and abiotic degradation due to properties such as low water solubility and volatility (Valera et al., 2013a). Consequently, they enter the food chain and accumulate mainly in animal tissues (Luzardo et al., 2012a). PCBs are mixtures of up to 209 different congeners, although only 36 are environmentally relevant (Kimbrough, 1995). OCPs include DDT and their metabolites (mainly *p,p′*-DDE), cyclodiene pesticides (aldrin, dieldrin, endrin) and hexachlorocyclohexane derivatives (HCHs; such as the γ-isomer also known as lindane). The use of OCPs and PCBs is now banned in most developed countries, but they are still widespread in the environment (Jaga and Dharmani, 2003, Almeida-González et al., 2012).

Some environmental exposures increase the risk of developing high blood pressure (BP). Although the results are inconclusive, there are many studies suggesting that chronic POP exposures is associated with hypertension (Huang et al., 2006; Everett et al., 2008; Ha et al., 2009; Valera et al., 2013a, 2013b). An association between hypertension and serum PCB concentrations has been suggested (Goncharov et al., 2010, Valera et al., 2013a); however, the results are less evident for OCPs. Thus, only β-hexachlorocyclohexane (β-HCH) and *p,p′*-DDE have been related with hypertension (Goncharov et al., 2011; Lind et al., 2014;). However, other studies suggest that OCPs may exert contradictory effects on BP (Valera et al., 2013a, 2013b).

The mechanisms responsible for this relationship have not been clearly elucidated, although endothelial dysfunction has been observed in some studies as a result of PCB exposure (Hennig et al., 2002; Andersson et al., 2011). However, there is no data describing the molecular mechanisms that would explain the relationship between OCPs and BP. Most OCPs may alter the endocrine system, i.e. the delicate balance of sex hormones (Marino et al., 2012) or modifying the growth hormone (GH) – insulin-like-growth factor (IGF) axis (Boada et al., 2007). OCPs have also been linked to diseases with elevated BP such as metabolic syndrome and obesity (Lee et al., 2007); consequently, metabolic syndrome (or obesity)-associated vascular changes may enhance susceptibility to BP risk factors.

Although the underlying causes of hypertension have not been conclusively determined, elevated BP is a major risk factor for death from cardiovascular disease (CVD) and stroke, and its incidence increases with age (Chowdhury et al., 2014). It should be highlighted that at least one in four Canarian adults suffered from hypertension, which is the worst it has been in over 65 years, as one in two elderly have high BP (Instituto Canario de Estadística, 2004). Thus, understanding the various factors that may alter BP is a key point to implementing preventive measures to reduce CVD morbidity.

In an attempt to explore the potential role exerted by the exposure to environmental POPs (mainly OCPs) on BP, we developed this population-based study in the adult Canary Islands population, who are highly exposed to non-DDT derivative pesticides (Luzardo et al., 2006) and demonstrate a high prevalence of metabolic syndrome and obesity (Álvarez-León et al., 2003).

2. Materials and methods

2.1. Study area

The Canary Islands are located 1600 km from southwest Spain in the Atlantic Ocean, hardly 100 km from the nearest point of the North African coast (southwest of Morocco) (Fig. 1). Geographically, the islands are part of Africa, yet from a historical, economic, political and socio-cultural point of view, the Canaries are European. The archipelago consists of seven major islands and other several small, uninhabited islands. The economy of the Canary archipelago is based fundamentally on a few economic sectors: tourism, and to a much lesser extent, farming, livestock production and fishing. Other economic sectors such as traditional polluting industries have a very limited presence in the islands.

2.2. Study group and data collection

Adult subjects from the Canary Islands, who were previously evaluated for BP and POP serum levels (aged ≥ 18 years; $n=428$, 191 men and 237 women) were selected among the representative population sample that had enrolled in the Canary Islands Nutrition Survey (ENCA, 1998). The characteristics and methodology of this Nutritional Survey, and all of the data about POPs contamination in this population have been previously published (Zumbado et al., 2005; Luzardo et al., 2006; Henríquez-Hernández et al., 2011; Núñez-González et al., 2011).

The ENCA Nutritional Survey was conducted in 1998 in the seven major Canary archipelago Islands. The population between 6 and 75 years old, at the moment of the study, was approximately 1.3 million people. The sample was stratified in two stages, and it was representative of the population between 6 and 75 years of age for both genders. Thus, 1747 subjects participated in the first part of the study (Fig. 2). This part consisted in two individual interviews with questions about dietary variables, life habits, and health condition. In the second stage, the participants gave blood samples after a 12-h fast to determine biochemical and nutritional parameters as well as serum POP levels. In total, 783 subjects participated in this biochemical stage (participation rate 44.8%) (Serra Majem et al., 2000). Individual questionnaires regarding smoking, cardiovascular disease and medication were also administered to each participant. Anthropometric and clinical measurements were performed by a clinical assistant. Participant height and weight were measured in socks and underwear only. Body mass index (BMI) was calculated as the weight (kg) divided by the squared height (m). According to international recommendations (WHO, 1996), BP was measured at the dominant arm of the sitting participant using an automatic measuring device (Omron). Prior to BP measurement, subjects were asked to rest for 5 min. Each subject had two BP readings and the systolic and diastolic BP means were calculated. A detailed description of clinical, biological and socio-demographic variables is presented in Table 1.

OCPs and PCBs were measured in 682 and 607 subjects, respectively. The chemical analysis procedure has been previously reported (Zumbado et al., 2005;

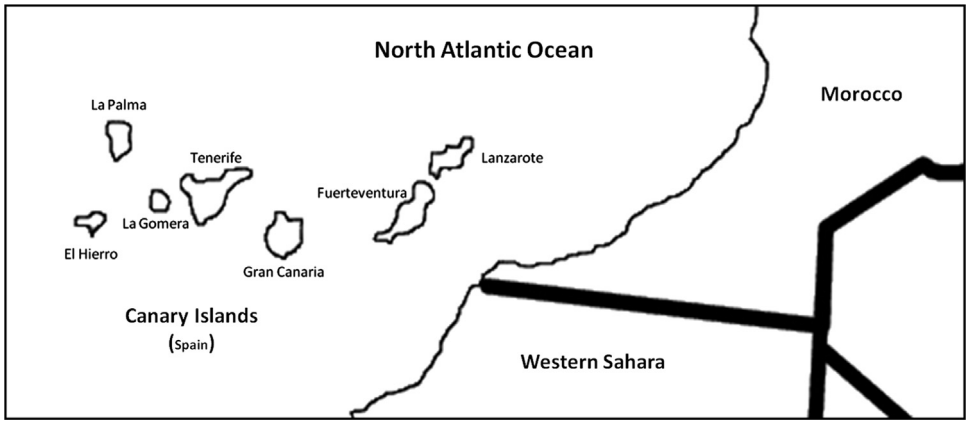

Fig. 1. Map of the Canary Islands.