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Review

Monitoring serum PCB levels in the adult population of the Canary Islands (Spain)

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Abstract: Polychlorinated biphenyls (PCBs) are persistent organic chemicals that have been detected in human serum or tissues all over the world. These pollutants could exert a number of deleterious effects on humans and wildlife, including carcinogenic processes. The Spanish population of the Canary Islands was evaluated with respect to PCB levels more than ten years ago showing lower levels than other Western populations. The objective of our study was to assess the current level of contamination by PCBs showed by this population. We measured serum PCBs in a sample of healthy adult subjects (206 serum samples from subjects with an average age of 66 years old) to evaluate the potential modification of PCB serum levels in this population during the last decade. PCB congeners (28, 52, 77, 81, 101, 105, 114, 118, 123, 126, 138, 153, 156, 157, 167, 169, 180, and 189) were measured by gas chromatography-mass spectrometry (GC/MS). Our results showed that PCB residues were found in 84% of serum samples analyzed, the congeners 28, 153 and 180 being the most frequently detected and at the highest median values (0.1 ng/mL). In addition, the median

concentration of the sum of those PCBs considered as markers of environmental contamination by these chemicals (Marker-PCBs) was 0.6 ng/mL, reaching values as high as as 2.6 ng/mL in the 95th percentile. Levels of the sum of PCBs with toxic effects similar to dioxins (dioxin-like PCBs) reached median values of 0.4 ng/mL in the 95th percentile. The reported levels are similar to those described previously in this population more than ten years ago, in the sense that the inhabitants of the Canary Archipelago show levels of PCB contamination lower than the majority of populations from developed countries. These findings suggest that currently there is not any active source of these chemicals in this archipelago. Nevertheless, as foods seem to be a relevant source for these compounds, Public Health authorities should monitor the presence of PCB residues in foods available in the market of these Islands.

Keywords: polychlorobiphenyls; POPs; serum samples; adult subjects; biomonitoring; gas chromatography/mass spectrometry

1. Introduction

Polychlorinated biphenyls (PCBs) are halogenated aromatic hydrocarbons widely used in closed systems such as electrical transformers, and capacitors, as well as in a large number of other applications: paints, fire retardants, etc [1,2]. The volatility of these compounds results in their evaporation from water surfaces and their movement through the atmosphere, resulting in widespread dispersal in the environment [2]. Furthermore, due to their fat solubility and resistance to chemical and biological degradation, ingestion of PCBs by animals leads to bioaccumulation throughout their lives and also to biomagnification in the food chain [1]. Due to these characteristics PCBs are considered as persistent organic pollutants (POPs) and were included in the Stockholm Convention [3].

PCB production decreased and eventually ceased in the 1970s [4]. In fact, they were banned in most Western countries (among them, Spain) in the late 1980s [5]. Currently, in addition to their ubiquitous presence in the environment, PCBs could also reach soils and waters as a result of leaks, spills, and improper disposal of old PCB-containing equipment. Furthermore, foods, mainly those of animal origin, are considered currently as a relevant source of PCBs for Western populations [6].

PCB exposure has been associated with adverse effects on human health. Thus, it has been found that PCB exposure could be related with the incidence of neurocognitive and endocrine disorders [7-10], and PCBs are considered as probable carcinogens to humans (Group 2A) by the International Agency for Research on Cancer (IARC), especially those PCB congeners that exhibit toxic actions similar to dioxins named dioxin-like PCBs (DL-PCBs) [11,12]. Additionally, several PCB congeners are known to be estrogenic and have been considered as endocrine disrupters [13].

The population of the Canary Islands in the context of a Nutritional Survey was extensively studied in 1998 about its level of contamination by POPs, including organochlorine pesticides [14-16]. Those studies indicated that the inhabitants of the Canary Archipelago showed levels of contamination by PCBs lower than the majority of populations from developed countries. In order to asses if there was any variation in POPs levels over the past decade, we have measured PCB serum levels in healthy adults enrolled as controls in a case-control study for bladder cancer developed in these Islands.

2. Materials and Method

2.1. Study area

The Canary Islands are located 1,600 kilometers away from southwest Spain, in the Atlantic Ocean, and hardly 100 kilometers from the nearest point of the North African coast (southwest of Morocco). Geographically, the Islands are part of the African continent; yet from a historical, economic, political and socio-cultural point of view, the Canaries are completely European. The Archipelago consists of seven major islands (the two capital Islands, Gran Canaria and Tenerife; and five other Islands, Fuerteventura, Lanzarote, La Palma, La Gomera, and El Hierro). The economy of the Canary Islands 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 [14].

2.2. Study group and sample collection

The study population was the healthy controls (206 adult subjects, 38 women and 168 men residents in these Islands at least during the last ten years) enrolled in a case-control study developed in the most populated island of the Canary Archipelago (Gran Canaria Island). All the details about the selection and criteria of inclusion in the case-control study have been described elsewhere [16].

The subjects included in the control group were contacted and asked to participate in the study, to sign the informed consent document, and to complete the specific questionnaire developed *ad hoc* (including questions about the most widely known POPs-related lifestyle). Thus, the questionnaire collected data on professional activities, and dietary habits. The study was approved by the Research Ethics Committee of the Complejo Hospitalario Universitario Insular Materno-Infantil. The participants had blood samples extracted after 12-hour fasting in order to determine the presence of

Table 1. Characteristics of the study population (*n* = 206).

	N (%)
Gender	
Male	168 (81.6)
Female	38 (18.4)
Habitat	
Rural <10,000 inhabitants	7 (3.4)
Semi-rural 10-100,000 inhabitants	38 (18.4)
Urban > 100,000 inhabitants	161 (78.2)
	Mean* ± *SD
Age (years old)	66.7±12.1
BMI (kg/m^2)	26.3±3.3

residues of POPs. The PCBs were measured in 206 subjects. The sociodemographic characteristics of the study subjects are shown in Table 1.

2.3. Sample preparation and analytical procedures

The aliquots of serum were subjected to solid-phase extraction as described previously [5] and analyzed by gas chromatography/mass spectrometry (GC/MS) using appropriate internal standards [5]. The analytes included in this study were the PCB congeners with IUPAC numbers #28, 52, 77, 81, 101, 105, 114, 118, 123, 126, 138, 153, 156, 157, 167, 169, 180, and 189. Chromatographic analysis was performed using a Thermo-Finnigan TRACE DSQ GC/MS instrument as previously reported [17,18]. We considered the limit of quantification (LOQ) as 10-fold the standard deviation of the blank. The LOQ for PCB congeners 28, 52, 101, 118 and 138 was 0.010 ng/mL; for PCB congeners 153 and 180, it was 0.005 ng/mL. The LOQ for the rest of analytes was 0.001 ng/mL.

In this work we express the total PCB body burden (∑PCBs) as the sum of the 18 PCBs measured (IUPAC congeners #28, 52, 77, 81, 101, 105, 114, 118, 123, 126, 138, 153, 156, 157, 167, 169, 180 and 189), Marker PCB body burden (∑M-PCBs) as the sum of those congeners considered as markers of environmental contamination for PCBs (IUPAC congeners #28, 52, 101, 118, 138, 153 and 180), non-ortho dioxin-like PCBs as the sum of the 4 non-ortho congeners measured (IUPAC congeners #77, 81, 126 and 169), mono-ortho dioxin-like PCBs as the sum of the eight mono-ortho congeners measured (IUPAC congeners #105, 114, 118, 123, 156, 157, 167 and 189), and DL-PCBs body burden as the sum of the 12 DL-PCBs (IUPAC congeners #77, 81, 105, 114, 118, 123, 126, 156, 157, 167, 169 and 189) measured.

2.4. Statistical analysis

Database management and statistical analysis were performed with PASW Statistics v 22.0 (SPSS Inc., Chicago, IL, USA). As serum PCB levels do not follow a normal distribution, the results are expressed with the median, and the 5th and 95th percentiles (p5 and p95, respectively). In addition, a zero value was assigned to all the values below LOQ, as previously reported [5]. Differences in the PCB levels between two groups or more were tested with the non-parametric Mann-Whitney U-test and Kruskal Wallis test. The categorical variables are presented as percentages and were compared between variables with the chi-squared test. P value of less than 0.05 (two-tail) was considered to be statistically significant.

3. Results and Discussion

As shown in Table 2, in our series we note that the frequency of detection of the M-PCBs was high, with more than 80% of the study population showing detectable values of this type of PCBs. No significant differences in PCB values among PCBs (individually or grouped) and the rest of variables recorded (gender, habitat, age) were found.

It has to be highlighted that congeners 28, 138, 153 and 180, were detected in a similar

percentage of subjects (more than 70% of the adult subjects included in the study). These results agree with our results described previously in that population [19]. Except in the case of PCB-28, which was detected in a much lower proportion in our previous study (6% of the samples). In addition, it has drawn our attention that PCB-28 was also found at concentrations as high as 0.5 ng/mL in the subjects included in percentile 95.

As shown in Table 2, the most toxic and carcinogenic compounds, that is PCBs similar to dioxins, were detected near to 70% of the subjects. This result is of concern because of the adverse health effects attributed to DL-PCBs [20]. Even more so, having into account that those subjects included in percentile 95 may show levels of these carcinogens as high as 0.4 ng/mL.

Table 2. PCB serum levels (ng/mL) and frequency of detection found in the adult subjects enrolled in the present study (average age 66 years old; *n* = 206). In addition data from the previous study developed in 1998 are shown (average age 65 years old; *n* = 116).

		Present series		Series of 2011
Group of PCBs	**Congener**	**Frequency (%)**	**Median (p5-p95)**	**Median (p5-p95)**
Marker-PCBs		**84.0**	**0.6 (0.0-2.6)**	**0.6 (0.0-3.0)**
	PCB-28	76.7	0.1 (0.0-0.5)	0.0 (0.0-0.01)
	PCB-52	39.8	0.0 (0.0-0.1)	0.0 (0.0-0.0)
	PCB-101	27.2	0.0 (0.0-0.02)	0.0 (0.0-0.06)
	PCB-118	65.0	0.0 (0.0-0.3)	0.0 (0.0-0.2)
	PCB-138	74.3	0.0 (0.0-0.5)	0.0 (0.0-1.3)
	PCB-153	74.8	0.1 (0.0-0.8)	0.3 (0.0-1.3)
	PCB-180	71.4	0.1 (0.0-0.8)	0.1 (0.0-0.3)
DL-PCBs (non-ortho)		**16.0**	**0.0 (0.0-0.002)**	**0.0 (0.0-0.4)**
	PCB-77	1.5	0.0 (0.0-0.0)	0.0 (0.0-0.0)
	PCB-81	4.4	0.0 (0.0-0.01)	0.0 (0.0-0.4)
	PCB-126	9.2	0.0 (0.0-0.02)	0.0 (0.0-0.0)
	PCB-169	1.9	0.0 (0.0-0.0)	0.0 (0.0-0.0)
DL-PCBs (mono-ortho)		**67.5**	**0.0 (0.0-0.4)**	**0.0 (0.0-0.4)**
	PCB-105	1.5	0.0 (0.0-0.0)	0.0 (0.0-0.0)
	PCB-114	6.3	0.0 (0.0-0.02)	0.0 (0.0-0.0)
	PCB-118	65.0	0.0 (0.0-0.3)	0.0 (0.0-0.2)
	PCB-123	6.3	0.0 (0.0-0.02)	0.0 (0.0-0.0)
	PCB-156	8.3	0.0 (0.0-0.03)	0.0 (0.0-0.2)
	PCB-157	15.5	0.0 (0.0-0.05)	0.0 (0.0-0.0)
	PCB-167	0.5	0.0 (0.0-0.0)	0.0 (0.0-0.6)
	PCB-189	6.8	0.0 (0.0-0.01)	0.0 (0.0-0.0)
Total DL-PCBs		**67.5**	**0.0 (0.0-0.4)**	**0.0 (0.0-0.7)**
Total PCBs		**84.0**	**0.6 (0.0-2.6)**	**0.7 (0.0-3.9)**

As in our previous works, the present findings indicate that serum PCB levels from people living in the Canary Islands are lower than those reported for other populations, probably due to the fact that there is a limited presence of industrial sources of PCBs in these Islands [19].

These low levels of contamination by PCBs could be due to the dietary patterns of the

population under study because diet seemed to be the major source of these chemicals for populations all over the world. A number of studies have reported extensive data on concentrations of PCBs in food samples [18,19,21,22].

Nowadays, it is considered that the consumption of fish is likely to be the most relevant source of PCBs for human beings [22-24]. Fish consumption is lower in the population of the Canary Islands [25] compared to the mainland Spanish population [26], which could at least partially explain the low PCB body burden in the Canary population. Nevertheless, further studies on this aspect are necessary to evaluate the role played by dietary habits as determinants of serum PCB levels.

4. Conclusions

In the present study, concentrations of PCBs were measured in the serum of adult healthy people from the Canary Islands. Our results show that the overall levels of these persistent pollutants are low as described previously for this population, suggesting that e main sources of PCBs for this population (industrial activity and food), remain little relevance in this Islands. In any case, the contribution of PCBs through food may help to explain why these levels have not decreased clearly in the last ten years.

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Conflict of Interest

All authors declare no conflicts of interest in this paper.

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