Concentrations of PCDDs, PCDFs and PCBs in human perinatal samples from Faroe Islands and Berlin

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1. Introduction

Little is known about prenatal transfer of PCDDs, PCDFs and PCBs from mother to fetus. Indeed these compounds have been measured in fetal and newborn tissues[1,2,3], but no maternal samples were available for comparison. PCBs have been analysed in maternal and umbilical cord blood, but in these earlier studies, single congeners were not measured[4,5] or the concentrations were not expressed on lipid basis[6] which is necessary to compare maternal and fetal body burden. In non-human primates, low prenatal transfer of PCDDs and PCDFs to fetal tissues was also measured on a wet weight basis[7]. Here we report on concentrations of PCDDs, PCDFs and PCBs (lipid based) in maternal samples (blood, milk), placenta and newborn samples (umbilical cord blood, meconium) of three mother/child pairs.

2. Experimental conditions

Three term newborns were studied (gestational ages 39 to 42 weeks, body weight 2980 g to 4000 g) after pregnancies without major problems. Woman A (age 27 years) comes from Torshavn (Faroe Islands), but has lived in Copenhagen for the last eight years (nutrition similar to that in native land). Woman B (age 31 years, of Greek origin) has lived in Germany for the last five years. Woman C (age 34 years) is from Germany. Umbilical cord blood (as much as possible) was collected from the cord directly after ligature by venipuncture with a big lumen tubule. Maternal blood (at least 40 ml) was taken within one hour after birth by venipuncture (no food had been ingested for at least eight hours). All blood samples were collected in heparinised vials. Additionally, a small amount of serum was obtained for analysis of cholesterol and triglycerides (Table 1). The entire umbilical cord and at least 100 g of placental tissue were frozen immediately at -18°C until analysis. Meconium collected in diapers was also frozen and later lyophilysed. Mother's milk (approximately 100 ml) was collected 4 to 7 weeks after delivery.

Analyses for PCDDs, PCDFs and PCBs were carried out using 40 ml whole blood (only 10 ml were available from newborn B). The blood samples were spiked with ^{13}C-labelled internal standards and then applied on a Chem Elute (modified Silicagel) column. The blood lipids were eluted with hexane/isopropanole. Freeze-dried meconium was mixed with sodium sulfate and spiked with ^{13}C-labelled internal standards. The extraction was performed by use of a hexane/acetone mixture on a

Soxhlet apparatus. Original placenta was mixed with sodium sulfate, spiked with ^{13}C-labelled internal standards and eluted with a mixture of cyclohexane/dichloromethane. Mother's milk was extracted according to the method of Fürst et al[8,9]. It involves liquid/liquid extraction of ^{13}C-labelled internal standards spiked milk with ethanol, diethylether and pentane. The lipid extracts from blood, meconium, placenta and milk were determined gravimetrically. The following clean-up involved a multicolumn system including a carbon column. Separation of planar molecules (such as PCDDs/PCDFs and non-ortho PCBs) from nonplanar (mono- and diortho PCBs) was performed on the carbon column.

The measurements of PCDDs/PCDFs and non-ortho PCBs were carried out by means of a HRGC/HRMS involving a DB 5 silica column coupled with a VG AutoSpec mass spectrometer. Mono- and diortho PCBs have been measured by HRGC/MS on an Ulta 1 silica column coupled with a HP 5970 mass spectrometer. Quantifications were performed using the isotope dilution method including an external standard mixture containing all PCDD/PCDF and PCB standards in question. The detailed methods are described elsewhere[10,11,12]. Quality control and quality assurance is ensured by participation on national and international quality control studies.

2378-T4CDD toxicity equivalents (TEs) for PCDDs/PCDFs were calculated using I-TEFs[13]. Concentrations below the limit of detection (LD) were taken in consideration as one half of the value defining the limit of detection.

Table 1 Concentrations of cholesterol and triglycerides in serum, hematocrit and concentrations of extracted lipids in whole blood of mother and newborn (umbilical cord blood)

	A		B		C	
	mother	cord blood	mother	cord blood	mother	cord blood
Cholesterol (mg/dl serum)	389	91	283	n.m.	361	74
Triglycerides (mg/dl serum)	194	39	180	n.m.	268	32
Hematocrit	0.37	0.45	0.41	0.50	0.35	0.49
Lipids extracted (mg/dl whole blood)	863	275	446	302	573	256

n.m. = not measured

3. Results and discussion

Concentrations of PCDDs, PCDFs and PCBs in perinatal samples are shown in Table 2 (mother/newborn A) and Table 3 (mother/newborn B and C, values of meconium and mother's milk are not ready at the time of submission). Extractable lipid content of the umbilical cord was too low (0.072% in A) to get reliable results.

Concentrations of PCDDs, PCDFs and PCBs in *mother/child pair A* were only slightly lower in cord blood than in maternal blood for most congeners, with a tendency toward lower transfer rates for the higher chlorinated compounds (less than 50% for OCDD and PCB 180 only). This finding is in agreement with Needham et al[14] who found 2378-T4CDD concentrations in the same range on a lipid basis in maternal and cord blood of an exposed mother/newborn pair. The same result was found for

PCBs in earlier investigations[4,5]. Concentrations in meconium lipids were only slightly lower than those in cord blood. Obviously meconium is also suitable for a representative analysis of body burden concentrations in newborns. Maternal milk which was collected seven weeks after delivery contained unexpectedly higher concentrations of PCDDs, PCDFs and PCBs than maternal blood at delivery. Further investigations are necessary to comment on this.

Prenatal transfer rates in *mother/child pairs B and C* (31% and 51% for I-TE, respectively) were lower than those of mother/child pair A (83%). One reason may be an individual variation in the extent of prenatal transfer. However, amounts of extracted lipids in umbilical cord blood were higher (approximately three times in newborn B and two times in newborn C) than expected from maternal values. Usually umbilical cord blood lipid values are about one quarter of the values in maternal blood (e.g., Olegård and Svennerholm[15]), as also found for cholesterol and triglyceride concentrations in our samples (Table 1). On the basis of such values, prenatal transfer rates of about 100% on lipid basis would be calculated also in mother/child pairs B and C (transfer rates on whole blood basis are about 25%, as found by others [e.g. 6]). The reasons for the unexpected high lipid amounts extracted from cord blood of infants B and C remain unclear and require further investigations.

In all *placental samples* concentrations of 2378-T4CDD were found to be higher than those in maternal blood. In mother A higher concentrations were measured also for 23478-P5CDF and 12378-P5CDD. This finding suggests certain binding structures (presumable the Ah-receptor) in the placenta as in other organs[16] which lead to higher placental concentrations of the most toxic congeners (with the highest receptor affinity) than expected from its lipid content. This has already been reported by Neubert et al[17], who measured PCDD/PCDF concentrations in adipose and placental tissues.

Despite a higher consumption of fish and whale products, the concentrations of PCDDs, PCDFs and PCBs in mother A (from Faroe Islands) did not differ from those in mothers B and C. This finding was anticipated, on the basis of other measurements in human milk samples from Faroe Islands in which slightly higher values were found for PCBs only[18].

4. References

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Table 2 Concentrations of PCDDs, PCDFs and PCBs in mother's blood, placenta, umbilical cord blood, meconium and mother's milk (based on extracted lipids, see discussion) in mother/child pair A

Compound (Conc. in pg/g fat)	Sample set A mother's blood	placenta	umbilical cord blood	meconium	mother's milk
2378-T4CDF	<2.6	<2.4	n.a.	<2.8	<1.0
2378-T4CDD	1.3	3.0	1.6	1.4	3.0
12378-P5CDF	n.n.(1.0)	n.n.(0.3)	<1.0	n.n (1.0)	0.34
23478-P5CDF	7.4	9.2	6.3	4.3	20.5
12378-P5CDD	4.2	6.4	3.0	3.2	8.3
123478-H6CDF	3.7	3.0	3.0	2.2	7.2
123678-H6CDF	2.5	2.1	2.3	1.8	5.2
234678-H6CDF	1.1	1.0	1.7	1.0	2.7
123478-H6CDD	4.0	3.6	3.0	2.5	8.3
123678-H6CDD	17.1	11.2	11.9	9.9	35.8
123789-H6CDD	3.2	2.7	2.7	2.2	4.9
1234678-H7CDF	4.7	3.3	5.2	4.3	4.8
1234678-H7CDD	17.8	11.6	10.7	12.2	52.4
OCDF	<2.1	<3.6	<5.0	<5.0	<1.0
OCDD	300	137	91.9	152	250
*I-TE (<LD=0.5*LD)*	*10.9*	*13.5*	*9.0*	*7.7*	*24.7*
PCB 77	9 (m)	13 (m)	21 (m)	65 (m)	5 (m)
PCB 126	73	57	90	77	213
PCB 169	117	61	65	53	166
(Conc. in ng/g fat)					
PCB 105	10.4	6.2	7.3	6.3	8.0
PCB 118	37.1	20.2	32.7	22.6	67.6
PCB 156	9.3	n.a.	10.9	n.a.	n.a.
PCB 28	3.5	0.9	3.6	n.a.	5.1
PCB 52	2.3	1.8	1.8	n.a.	2.7
PCB 101	4.6	3.5	3.6	8.8	6.0
PCB 138	176	77	131	91	288
PCB 153	222	112	142	106	329
PCB 180	130	63	69	64	155

n.a. = not analysed
n.d. = not detected (limit of detection)
(m) = maximum value, due to possible contribution of a contaminent

Table 3 Concentrations of PCDDs, PCDFs and PCBs in mother's blood, placenta and umbilical cord blood (based on extracted lipids, see discussion) in mother/child pair B and C.

Compound (Conc. in pg/g fat)	Sample set B mother's blood	placenta	umbilical cord blood	Sample set C mother's blood	placenta	umbilical cord blood
2378-T4CDF	<2.5	1.3	<2.0	<1.5	<1.0	<2.0
2378-T4CDD	2.2	3.0	<1.0	1.3	2.1	<1.0
12378-P5CDF	<1.0	n.n.(1.0)	<1.0	n.n.(1.0)	<1.0	<1.0
23478-P5CDF	8.5	6.6	2.2	9.5	8.2	4.5
12378-P5CDD	4.8	3.0	2.0	4.6	4.1	2.8
123478-H6CDF	5.2	2.3	1.9	5.1	2.3	3.2
123678-H6CDF	3.7	1.6	<1.0	3.5	1.5	2.4
234678-H6CDF	1.4	<1.0	<1.0	<1.0	<1.0	<1.0
123478-H6CDD	4.3	1.7	2.4	4.2	2.2	2.5
123678-H6CDD	16.5	7.0	4.9	21.3	7.9	9.9
123789-H6CDD	3.7	1.3	<3.0	3.0	1.0	<2.5
1234678-H7CDF	6.7	2.0	<4.0	4.7	<1.2	5.8
1234678-H7CDD	42.6	16.9	9.3	18.6	6.5	7.0
OCDF	<2.5	<2.8	n.a.	<2.5	<2.8	<4.0
OCDD	452.0	110.0	72.0	348.0	95.7	117.0
*I-TE (<LD=0.5*LD)*	*13.4*	*9.7*	*4.1*	*12.8*	*10.0*	*6.5*
PCB 77	12 (m)	n.a.	10 (m)	10 (m)	10 (m)	10 (m)
PCB 126	114	61	23	43	18	21
PCB 169	44	14	9	81	23	33
(Conc. in ng/g fat)						
PCB 105	5.8	3.6	3.8	2.8	1.1	1.3
PCB 118	23.2	11.3	13.8	13.1	4.9	7.3
PCB 156	12.1	6.7	5.9	3.7	n.a.	n.a.
PCB 28	<8.4	<16.9	<13.3	<5.3	<5.3	<4.2
PCB 52	<1.5	<8.3	n.n.(5)	<1.8	<3.4	n.n.(2)
PCB 101	<2.6	<11.2	<8.1	<1.3	<1.8	n.n.(2)
PCB 138	83	41	36	213	64	119
PCB 153	113	55	48	257	89	153
PCB 180	62	23	15	170	51	70

n.a. = not analysed
n.d. = not detected (limit of detection)
(m) = maximum value, due to possible contribution of a contaminent

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