Effects of perinatal PCB and dioxin exposure and early feeding mode on child development
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Chapter 9

The previous chapters in a nutshell

Polychlorinated biphenyls (PCBs) and dioxins are toxic environmental pollutants (chapter 1). PCBs and dioxins pass the placenta, and relatively large amounts are transferred from the breast-feeding mother to her child. Formula milk is free of these substances. PCBs are strongly lipophilic and very resistant to biological breakdown. In this thesis - which is part of the international ‘PCB/Dioxin-Breast Milk Study’ - the effects of prenatal exposure to PCBs and lactational exposure to PCBs and dioxins on child development are investigated in a group of 42-month-old children who have been followed from birth. Both neurological and cognitive functioning were taken as developmental parameters. In addition, the effect of early type of feeding on long-term neurological development was investigated.

Earlier studies indicated that greatest risks of PCBs are associated with prenatal exposure. In spite of this, there are no data available on the distribution of PCBs among the fetal internal organs and the relationship between fetal PCB levels and gestational age. We therefore collected subcutaneous adipose tissue, liver and brain tissue from nine stillborns of varying gestational ages. PCB levels in brain, expressed as ng/g fat, amounted to 20% of that in subcutaneous adipose tissue. For liver this was 80%. The congeneric distribution pattern of PCBs did not differ among the organs. The differences in PCB levels between the organs probably indicate the affinity of PCBs for highly apolar fats like triglycerides. There were no significant relationships between PCB levels in each of the fetal compartments and gestational age. PCB levels in fetal adipose tissue were in the same range as that found in breast milk fat from 93 Dutch mothers. From these results it may be concluded that PCBs are easily transferred across the placenta and that they seem to become equilibrated among the apolar parts of fetal and maternal lipids, notably triglycerides (chapter 2).

In 42-month-old children that have been fully breast-fed for at least six weeks, the median plasma PCB level was 4½ times as high as that in plasma obtained from formula-fed children (0.81 versus 0.18 µg/L, respectively). In our data, PCB levels at 42 months could be estimated with help of the following equation:
\[ \Sigma_{PCB_{42\,mo}} = 0.429 \text{ (standard error (SE)=.149)} \times 0.820 \text{ (SE=.281)} \times \Sigma_{PCB_{cord\,plasma}} 0.544 \text{ (SE=.136)} + 0.0028 \text{ (SE=.00055)} \times FBF \times \Sigma_{PCB_{breast\,milk}} \]

where FM stands for feeding mode (breast-fed=0, formula-fed=1) and FBF stands for the number of weeks of full breast-feeding. \( \Sigma_{PCB} \) is the sum of the PCB congeners #118, 138, 153, and 180 in \( \mu g/L \). Other - maternal - factors did not influence the child’s plasma PCB level. Therefore, lactation is a major source of PCBs. The plasma PCB level in preschool children seems to depend on the duration of full breast-feeding, and the PCB levels in cord plasma and breast milk (chapter 3).

Three hundred and ninety four 42-month-olds were neurologically examined by means of the technique according to Touwen and Hempel. 381 (97\%) of the children were diagnosed as neurologically normal, 12 (3\%) showed mild signs of neurological deficit which did not lead to a handicapping situation, and 1 (<1\%) had a circumspect neurological syndrome (that is diplegia). We also evaluated the neurological condition in terms of optimality. For this we used a list of 56 pre-set criteria for optimality. For each child a neurological optimality score was established by counting the number of items considered optimal. Neither prenatal exposure to PCBs nor postnatal exposure to PCBs and dioxins was associated with the neurological optimality score. In our data, adverse effects of perinatal exposure to PCBs and dioxins on the neurological condition at 42 months could not be detected (chapter 4).

In 395 42-month-olds the cognitive abilities were measured. For this the Kaufman Assessment Battery for Children (K-ABC) was used. The K-ABC assesses two types of mental functioning, sequential and simultaneous processing. Both add up to the overall cognitive score. Univariately, the score on each of the three scales was significantly higher for breast-fed than for formula-fed children. After adjusting for confounding variables, we found negative associations between prenatal PCB exposure and the scores on the cognitive as well as on the sequential and the simultaneous scales. Higher levels of prenatal PCB exposure therefore seem to be related to poorer cognitive functioning at 42 months of age (chapter 5).

Breast milk not only is a source of PCBs and dioxins, but it also provides the infant with substances that are essential for optimal growth and development. We investigated the effect of breast-feeding on neurological development in two study populations. Firstly, we studied neonatal and nine-year neurological follow-up data that had been gathered by
investigators working on the so called ‘Perinatal Project Groningen’. In this project a large group (n=3162) of children, born at the University Hospital Groningen between 1975 and 1978, was followed from birth. A group of healthy term children was selected from this cohort; 66 children diagnosed as neurologically abnormal and 213 children who showed slight abnormalities at the neonatal examination were available for analysis. A group of 247 neurologically normal neonates served as a reference. We assessed the type of feeding and the duration of breast-feeding in retrospect after a period of about 18 years. Recall of breast-feeding practices has previously been found to be reliable even after a period of 18 years. Breast-feeding (for ≥3 weeks) was negatively related to neurological non-normality at nine years of age (odds ratio for neurological non-normality 0.54; 95% confidence interval 0.30-0.97), and, more specifically, to the more severe form of minor neurological dysfunction at that age (chapter 6). Although definite conclusions could not be drawn due to the partial retrospective design, these findings suggest that breast-feeding during the first weeks of life has a small beneficial effect on neurological development.

In view of this, we also investigated the relationship between early feeding mode and the neurological condition in a prospective manner, using the 42-month data from the ‘PCB/Dioxin-Breast Milk Study’. In contrast to the first study on the effect of breast-feeding, in these investigations the study population consisted almost exclusively of children who were diagnosed as neurologically normal at the neonatal examination. We found a negative relationship between breast-feeding and a less-optimal fluency score (odds ratio for non-fluency 0.56; 95% confidence interval 0.37-0.85). Therefore, our data indicate a small beneficial effect of breast-feeding on the fluency of movements (chapter 7). The prolongation of full breast-feeding beyond six weeks did not improve the quality of movements. Altogether, breast-feeding seems to have a small advantageous effect on long-term neurological development.

Environmental exposure to PCBs might influence women’s ability to lactate. PCBs have been found to exert oestrogenic effects, and oestrogens are known to suppress lactation. Furthermore, from animal studies we have indications that dioxin-like substances such as planar PCBs affect the fat metabolism. It is unknown whether this also applies to the human mammary gland. We investigated the relationships between maternal PCB exposure on the one hand, and breast milk volume and the content of the two most abundant fats in breast milk, triglycerides and cholesterol, on the other. For this, breast milk was sampled from 102 healthy mothers. The maternal PCB body load, as determined from the
PCB level in breast milk fat, not only was inversely related to the 24-h breast milk volume, but also to the milk triglyceride content. PCB exposure was unrelated to the cholesterol level. Therefore, our data suggest that human breast milk volume and fat content are negatively affected by the presently encountered PCB levels in the Dutch population (chapter 8). More research is needed to replicate our findings and to investigate the mechanisms behind the relationships.