PRACE ORYGINALNE
ORIGINAL PAPERS

Medycyna Środowiskowa - Environmental Medicine 2013, Vol. 16, No. 1, 17-21
www.medycynasrodowiskowa.pl www.environmental-medicine-journal.eu

Old and New Contaminants in Human Milk

Dawniejsze i nowe zanieczyszczenia pokarmu matczynego

Karl Ernst v. Muehlendahl [(a, b, c)], *Matthias Otto* [(a, b, c)]

Kinderumwelt GmbH, German Academy of Pediatrics e.V. (DAKJ)

Contributions of authors:
(a) Idea
(b) Collection of material for research
(c) Working on text and references

SUMMARY

During the last 30 years, concentrations of toxic chlorinated organic pollutants, also known as persistent organic pollutants (POPs) in breast milk have markedly decreased. This holds true for dichlorodiphenyltrichloroethane (DDT), hexachlorobenzene (HCB), polychlorinated biphenyls (PCB), beta-hexachlorocyclohexane (beta HCH) and polychlorinated dibenzo-p-dioxines and dibenzofuranes (PCDD/F). However, residues and pollutants originating from new classes of chemical products which are produced in quantities of 100.000s up to millions of tons per year have spread ubiquitously and are partly released into environment: flame retardants, fragrances, plasticisers, perfluorated tensides, and bisphenol A. All these substances can be detected in breast milk in small to nearly insignificant concentrations. Acute and medium-term health problems due to breast feeding are not to be expected. There are no toxicological reasons which could be taken as arguments against breast feeding.

Key words: Human milk, breast feeding, environmental pollutants, POPs in breast milk, POPs in human milk

STRESZCZENIE

W okresie ostatnich 30 lat w mleku matczynym znacznie zmalała koncentracja toksycznych chlorowcowych organicznych skażeń przez znane przetrwałe organiczne polutanty (POP). Odnosi się to do następujących związków: dichlorodiphenyltrichloroethane (DDT), hexachlorobenzene (HCB), polychlorinated biphenyls (PCB), beta-hexachlorocyclohexane (beta HCH) i polychlorinated dibenzo-p-dioxines i dibenzofuranes (PCDD/F). Jednak ich pozostałości oraz nowe polutanty pochodzące z nowych rodzajów związków chemicznych, które są wytwarzane w ilościach od 100.000 do miliona ton rocznie rozeszły się wszędzie i w części dostały się do środowiska: uniepalniacze, środki zapachowe, plastyfikatory, perfluorowane tenzydy, bisfenol A. Wszystkie te substancje mogą być wykrywane w mleku matczynym w małych, a nawet nieznacznych stężeniach. Ostre zatrucia albo dalsze następstwa zdrowotne wywołane karmieniem piersią nie są spodziewane. Nie ma przesłanek toksykologicznych, które uzasadniałyby obecność argumentów przeciwko karmieniu naturalnemu.

Słowa kluczowe: mleko ludzkie, karmienie piersią, polutanty środowiskowe, POP w mleku matczynym

INTRODUCTION

Monitoring of the content of persistent organochlorine pollutants (POPs) in human milk has been and is important for the health and safety of breast-fed infants. Moreover, breast milk has served as a useful matrix to determine changes over time in the environmental load of POPs. The content of several, meanwhile „classical“ contaminants (dichlorodiphenyltrichloroethane (DDT), hexachlorobenzene (HCB), polychlorinated biphenyls (PCB), beta-hexachlorocyclohexane (beta HCH) and polychlorinated dibenzo-p-dioxines and dibenzofuranes (PCDD/F)) has declined markedly. Exact data are detailed in a previous publication on this subject [1]. Three or two decades ago, some of these compounds were present in possibly harmful concentrations. Today, concentrations are below the level of concern, at least in German breast milk samples.

Nadesłano: 22.01.2013
Zatwierdzono do druku: 8.02.2013

However, new chemical compounds have been synthesised, released, and are present ubiquitously in our environment. They give reason for concern, because
– they are slowly degradable and hence stable over long time periods and appear also in our food chain;
– they are produced in large or very large quantities;
– they are biologically active and possibly toxic for mankind, fauna, and flora.

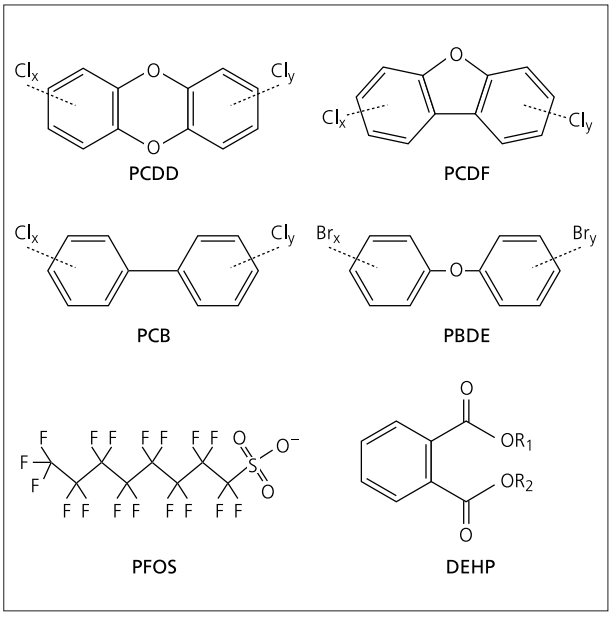

Fig. 1. Chemical structure of substances discussed in this paper
Ryc. 1. Struktura chemiczna substancji omawianych w pracy

Such substances are halogenated hydrocarbons, flame retardants, perfluorinated tensides, nitroaromatic substances (some fragrances), diesters of dicarbon acids (plasticisers, mainly phthalates), bisphenol A, and by-products of combustion processes (dioxins, furanes). All these substances are today detectable in human milk.

We will discuss the present state of knowledge and the question whether these substances constitute a threat to breast fed infants. Results come mainly from German data, but many – at least when describing tendencies – probably are correct also for other European countries.

Polychlorinated dibenzodioxines and dibenzofuranes and dioxin-like biphenyls (dl-PCB)

Dioxines and furanes are unwanted by-products of combustion processes in the presence of chlorine. In small amounts, dioxines and furanes were also present in pre-industrial times.

PCDD/F and dl-PCB immissions and concentrations in environmental matrices have declined markedly during the last twenty years. In adults, average uptake of PCDD/F and dl-PCB today amounts to 77 pg/kg/day. Thirty years ago, it was in the range of 200 pg/kg/day [2].

However, the possible load for formula-fed infants is still regarded as high. Applying the highest admitted concentration [2], a 3 months old infant would have an uptake of 35 pg/kg/day of WHO-PCDD/F-TEQ which is considerably higher than WHO TDI (1–4 pg/kg/day) or the SCF limit (2 pg/kg/day).

It has to be considered that TDI indications are valid for a life-long daily uptake. Infants are formula-fed for only a few months.

Resumee: As to breast feeding, WHO does not recommend any limitations due to the content of PCDD/F and dl-PCB.

Polybrominated diphenylethers (PBD) – flame retardants

Many commercial products contain PBD: plastics, namely casings of electric and electronic equipment, insulating foams, textiles, carpets etc. These lipophilic substances tend to evaporate and to accumulate in environmental matrices and in the food chain. Of octadiphenylbromether (OBDE) – just one congener among many – more than 60,000 tons have been produced and applied per year. Production and use of pentadiphenylbromether (PBDE) and OBDE are not allowed in the European Union since 2003, and worldwide since 2010. Further restrictions are under consideration.

PBDE can be detected ubiquitously, also in human milk. Since the seventies of the last century, there was a sharp rise of measurable concentrations, e.g. in Sweden: 1972 0.07 ng total PBDE per gram of human milk fat, 1997 4.02 ng/g [3]. Between 2001 and 2004, 1.7 ng/g, and 2006–2008 1.36 ng/g were found in Germany [4]. In England, concentrations were 6.4 ng/g, in the USA and in Canada concentrations were 10 to 100 fold higher.

Their toxicity is not well defined. High doses (100 to 1000 µg/kg/day) are neurotoxic, carcinogenic and endocrine disruptors to some experimental animals. Due to the heterogeneity of the different compounds, definition of a TDI ist not possible. The daily intake amounts to about 1 ng/kg/day.

Resumee: According to the German Umweltbundesamt and the Bundesinstitut für Risikobewertung the present content of flame retardants in human milk constitutes no health risk [5–7].

Musk fragrances

Many consumer products contain fragrances. World-wide, yearly several thousand tons of synthetic musk derivatives are produced. Those are nitromusk compounds, aromatic carbon rings with multiple NO_2-substitutes, most frequently musk ketone and musk xylol, as well as diverse polycyclic musk substances. Since many of these products occur simultaneously in fragrance products, it is difficult to estimate toxicities.

Musk xylol is out of use in the European Union since more than ten years. Further nitromusk derivatives and one of the polycyclic substances are not allowed in cosmetic products in the European Union since approximately ten years.

Musk substances are lipophilic and only slowly degradable. They are found world-wide in many environmental matrices. They accumulate in human and animal fat tissue and thus can also be detected in breast milk.

The acute toxicity for man is low [8]. As to chronic effects, neurotoxicity, mutagenicity and reproductive toxicity are discussed. For many musk compounds a definition of human toxicity is not possible at the moment. The peroral load is quantitatively much lower than the load due to transcutaneous absorption [9]. In human milk, concentrations are declining over time. In the nineties of the last century, concentrations for different musk substances were 0.03–0.1 mg/kg fatty substance in breast milk [10, 11].

Resumee: Daily uptakes range below few µg/kg/day and hence 10 to 100 fold below the preliminary TDI. Since transcutaneous absorption is considerably higher [9], it appears to be of much greater importance to avoid application of perfumed skin care products in infants, rather than to stress the breast milk aspect.

Phthtalates

Phthalates are hydrocarbons, esters of the 1,2 benzenedicarbonic acid (phthalic acid), they are not halogenated hydrocarbons. Originally, diethylhexylphthalate (DEHP) was the derivative with highest production rates, but the volumes are declining, and other derivatives as diisononylpthtalate (DiNP) and diisodecyphthalate (DiDP) are increasing. Worldwide several million tons are produced each year (2004: ca. 7 million tons) [12]. Ninety percent are used as softeners in plastic production, but phthalates are found in many other chemical products and customer products.

There is some uptake of phthtalates through the skin and by inhalation; but the main route is oral, e.g. of phthalates emanating from food packages. Also infusion and transfusion bags and tubings as used in medical therapy can be an important and unwanted source of very considerable amounts of phthalates. In prematures with intravenous nutrition DEHP uptake could amount to 10–20 mg/day, manifoldly exceeding the tolerable daily intake [13].

Hydrolytic cleavage of phthalates results in monoesters which are partly oxidised, then glucuronidised and relatively quickly excreted. They do not accumulate in the human body. In animal experiments they are toxic to liver, kidney, and testes, and they are weak endocrine disruptors.

Several phthalates and their metabolites can be detected in human milk in concentrations of some µg/l (maximally up to about 50 µg/l). Formula milk contains phthtalates in similar concentrations. There are not very many publications on breast milk contents; they show, over time, no clear tendency towards increasing or decreasing concentrations. The European Food Safety Agency (EFSA) has defined a tolerable daily intake (TDI) of 50 µg/kg/ for DEHP, based on a no observed adverse effect level (NOAEL) of 5 mg/kg as determined in animal experiments. For DiNP, the respective figures are 10 µg/kg and 2 mg/kg.

Resumee: Calculated intake of phthalates by breast fed infants and simililarly of formula fed infants [14] are by one or two magnitudes below the TDI margins.

Bisphenol A

BPA, object of many controversies since several years, is produced in very large amounts (several million tons per year world-wide). In Germany, 400,000 tons are used, mainly for the production of polycarbonates and epoxid resins.

Polycarbonates are widely used, among others in plastic bottles and other plastic containers for food and beverages. Metallic tins contain epoxid resins as inner coating. BPA is regularly found in food and beverages, usually in amounts of less than 3 µg/kg food, and sometimes up to 10 µg/kg.

For the pediatrician, BPA in baby bottles is of special interest. New polycarbonate bottles do not release measurable amounts of BPA, but after using such bottles for several years, BPA release is increasing, probably to maximally 10 µg/l, usually not more than 3 µg/l.

There are only scarce data on the BPA content in human milk; concentrations between 0.28 and 1.3 µg/l were found [15]. The resulting health risk for infants is regarded as negligible.

Acute toxicity of BPA is low, and it is not considered to be mutagenic or carcinogenic. It binds weakly to

estrogen receptors. High doses induce feminisation of reproductive organs in experimental animals. Whether the normal daily exposure of man is toxic or not is discussed controversially.

Much of the knowledge on BPA toxicity results from animal experiments. Recent investigations show substantial differences in sensitivity between rodents and man, due to quicker metabolisation in man as well as to the special sensitivity of mice against environmental agents with estrogenic effects. This must be kept in mind if results from animal toxicology are applied to man.

In Canada, Denmark, and France the use of BPA containing bottles for infant feeding has been preventively prohibited. Recommendations in Germany (Umweltbundesamt and Bundesinstitut für Risikobewertung) are equivocal. The Scientific Committee on Food (SCF) of the European Commission has issued a provisional TDI: 10 µg/kg. EFSA has raised this limit to 50 µg/kg.

Resumee. Infants' load with BPA by breast milk is low and, as to possible health effects, of no importance. Recommendations as to the use of polycarbonate bottles are equivocal. The low weight and the fact that they are unbreakable are to be taken into consideration.

Perfluorinated tensides (PFT)

Perfluorated substances (PFS) consist of aliphatic hydrocarbons in which all hydrogen atoms are substituted by fluorine. One of the best known products is Teflon R, a perfluoroalkane. In environmental medicine, perfluorated tensides are of importance; they are both hydrophilic and lipophilic and thus reduce surface tension. The most important compounds are perfluorooctanesulfurone acid (PFOS) and perfluorooctane acid (PFOA). PFT are present in many consumer products. Intake is possible orally (food), by inhalation (house dust), and transdermally at direct contact. PFT are persistent and meanwhile ubiquitously detectable. Because of the long environmental half life,

there exist manifold endeavours to reduce production and use of PFT.

There are not very many published investigations on measurements of PFT in human milk. PFOS and PFOA concentrations range approximately from 10-400 ng/l. Concentrations in simultaneous serum samples were markedly higher [16, 17, 18].

The acute toxicity is low. According to the present knowledge, PFOA and PFOS are genotoxic and cancerogenic only at cytotoxic concentrations; they have no primary genotoxic effects.. In animal experiments, at high doses hepatotoxic effects were occurring [19].

Because of knowledge deficits, the Umweltbundesamt has defined for general orientation a maximum concentration in drinking water of 0.1 µg/l for the sum of PFOA, PFOS, and further PFS. Water used for the preparation of infant food should not contain more than 0.5 µg/l [20]. The EFSA has defined TDI for PFOS of 0.15 µg/kg, for PFOA of 1.5 µg/kg; basis for this definition has been a safety factor of 200, with respect to the NOAEL.

Resumee. Fully breast fed infants have intakes that are lower by the factor 6 to 10 than the TDI definitions. Such amounts are considered not to be toxic for infants.

LONG TERM ASPECTS

The breast milk contaminants discussed in this paper are not acutely toxic for breast- or formula-fed infants. We must, however, consider the life long uptake by food, water, air, etc. and cancerogenicity, genotoxicity, endocrine disruption, modifications of the immune system of these substances.To discuss whether the observed increase in prevalence of malignant diseases or atopic disposition are due or partly due to such chemical environmental loads is not possible within the scope of this paper. Finally, it has to be stated that this publication clearly is anthropocentric. The undeniably considerable world-wide chemical load has much wider implications than human health only.

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Address for correspondence:
Prof. Karl Ernst v. Muehlendahl
Westerbreite 7, D 49084 Osnabrück
Tel. +49 541 9778900
e-mail: info@uminfo.de