FLUORIDE AND CALCIUM DISTRIBUTION IN HUMAN PLACENTA

Dariusz Chlubek,[a] Ryszard Poreba[b] and Bogusław Machalinski[a]
Szczecin and Tychy, Poland

SUMMARY: Fluoride and calcium concentrations in maternal plasma and in placental tissue were determined in 30 healthy women residing in an area with a relatively low water and air fluoride (fluorine) content. The mean fluoride concentrations in maternal plasma and in marginal and central parts of placenta were 4.27 μM/L, 42.1 μg/g of ash, and 33.7 μg/g of ash, respectively. The mean calcium concentrations in maternal plasma and in marginal and in central parts of placenta were 2.3 mM/L, 22.9 mg/g of ash, and 20.0 mg/g of ash, respectively. Fluoride contents of both parts of placental tissue differed significantly ($p < 0.05$). High positive correlations ($p < 0.001$) were found between maternal plasma fluoride concentration and the fluoride content of the marginal part of placenta as well as between maternal plasma calcium concentration and the calcium content of both parts of placental tissue. The same positive correlation was also found between fluoride and calcium contents of marginal part of placental tissue. Our data indicate that most placental fluoride is stored in the marginal part of the organ presumably as a result of the higher concentration of calcium found in that area.

Key words: Human placenta; Maternal plasma; Placental calcium; Placental fluoride; Plasma calcium; Plasma fluoride.

INTRODUCTION

Recently published studies on placental transfer of fluoride clearly show that fluoride passes through the placenta.[1-4] There is also evidence, however, that the placenta can accumulate fluoride and possibly play a regulatory role that helps protect the fetus from excessive amounts of fluoride, when maternal fluoride intake is high.[5-7] The purpose of the present study was to investigate placental accumulation and distribution of fluoride and calcium in healthy women residing in an area with a relatively low water and air fluoride (fluorine) content.

MATERIAL AND METHODS

The studies were performed on 30 healthy women at term, aged from 19 to 40 years residing in an area with < 0.5 ppm of fluoride in the drinking water and < 1.5 $\mu g/m^3$ of fluorine in the air. All women were hospitalized during the perinatal period and delivered by spontaneous labour. From each patient during the first period of normal delivery blood was drawn in tubes containing heparin as an anticoagulant. All blood samples were centrifuged for 10 minutes at 3000 rpm, and the plasma was stored at -20°C until fluoride and total calcium concentrations were determined. Placentas were obtained from all patients after birth and also stored at -20°C. Each placenta was divided into two parts: central and marginal. The fluoride and calcium content of both parts was determined by adding 10.0 mL of saturated solution of magnesium chloride, drying at 80°C for 48 hours and ashing at 600°C for 16 hours.

Ionic fluoride was determined in 1.0 mL of plasma with an equal volume of TISAB buffer, which adjusted the pH to 5.0. Total calcium was determined in 0.05 mL of plasma, which was diluted to 5.0 mL with distilled water.

---

[a] Department of Biochemistry and Chemistry, Pomeranian Medical Academy, Al. Powstancow Wielkopolskich 72, 70-111 Szczecin, Poland. [b] IVth Department of Obstetrics and Gynecology, Silesian Medical Academy, ul. Engelsa 102, 43-100 Tychy, Poland. Presented at the XXIst World Conference of the International Society for Fluoride Research, Budapest, August 25-29, 1996.

To determine the fluoride content of the placenta samples, 30.0 mg of ash was first dissolved in 1.0 mL of 2.0 M $HClO_4$, then 0.2 mL of the resulting solution was neutralized with 0.8 mL of 1.0 M aqueous sodium citrate, and finally 1.0 mL of TISAB buffer was added.

To determine the calcium content of placenta samples, 30.0 mg of ash was dissolved in 1.0 mL of 14 M HNO_3 for 48 hours, then heated to 70°C, and finally diluted with distilled water.

The levels of fluoride were determined with the Orion-96-09 fluoride-ion-selective electrode (Orion), and the levels of calcium were determined with an atomic absorption spectrophotometer PU 9100 X (Philips).

The results were statistically analysed by the Student's t-test and by Pearson's correlation coefficient. A probability value of < 0.05 was taken as indicating significance.

RESULTS

Concentrations of fluoride in maternal plasma, marginal part of placenta, and central part of placenta are presented in Table 1. Fluoride contents of both parts of placental tissue differed significantly ($p<0.05$). Calcium contents of maternal plasma, marginal part of placenta and central part of placenta are presented in Table 2.

A strong positive correlation ($p<0.001$) was found between fluoride concentrations in maternal plasma and marginal part of placenta (Figure 1). A strong positive correlation was also found between calcium concentrations in maternal plasma and marginal part of placenta (Figure 2) as well as between calcium concentrations in maternal plasma and central part of placenta (Figure 3). Figure 4 shows the high positive correlation between fluoride and calcium concentrations in marginal part of placenta ($p<0.001$).

TABLE 1. Fluoride concentrations in maternal plasma, marginal part of placenta, and central part of placenta

		Fluoride concentration					
	No. of cases	Mean	Median	SD	Min.	Max.	Range
maternal plasma [μM/L]	30	4.27	4.21	0.79	2.79	6.11	3.32
marginal part of placenta [μg/g of ash]	30	42.1	39.5	11.4	19.7	76.4	56.7
central part of placenta [μg/g of ash]	30	33.7	34.2	11.4	14.4	61.7	47.3

TABLE 2. Total calcium concentrations in maternal plasma, marginal part of placenta and central part of placenta

		Calcium concentration					
	No. of cases	Mean	Median	SD	Min.	Max.	Range
maternal plasma [mM/L]	30	2.3	2.3	0.2	1.8	2.8	1.0
marginal part of placenta [mg/g of ash]	30	22.9	21.5	7.5	12.2	49.0	36.8
central part of placenta [mg/g of ash]	30	20.0	19.3	4.9	12.3	33.2	20.9

FIGURE 1. Correlation between fluoride concentrations in maternal plasma and marginal part of placenta

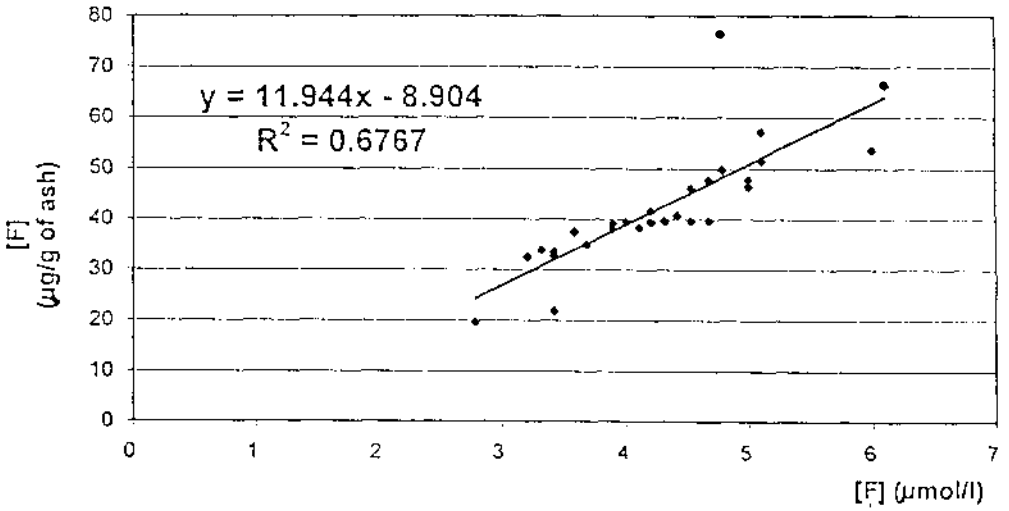


FIGURE 2. Correlation between calcium concentrations in maternal plasma and marginal part of placenta

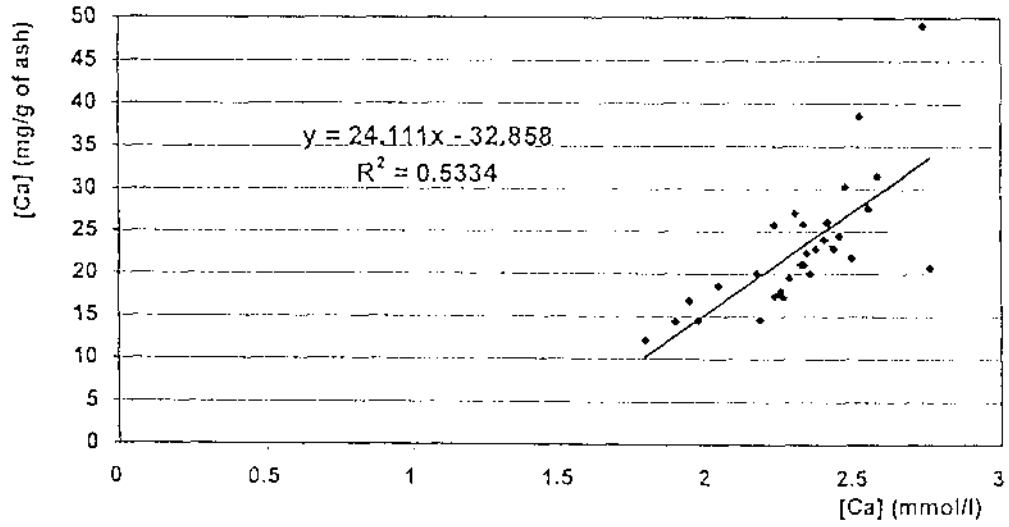


FIGURE 3. Correlation between calcium concentrations in maternal plasma and central part of placenta

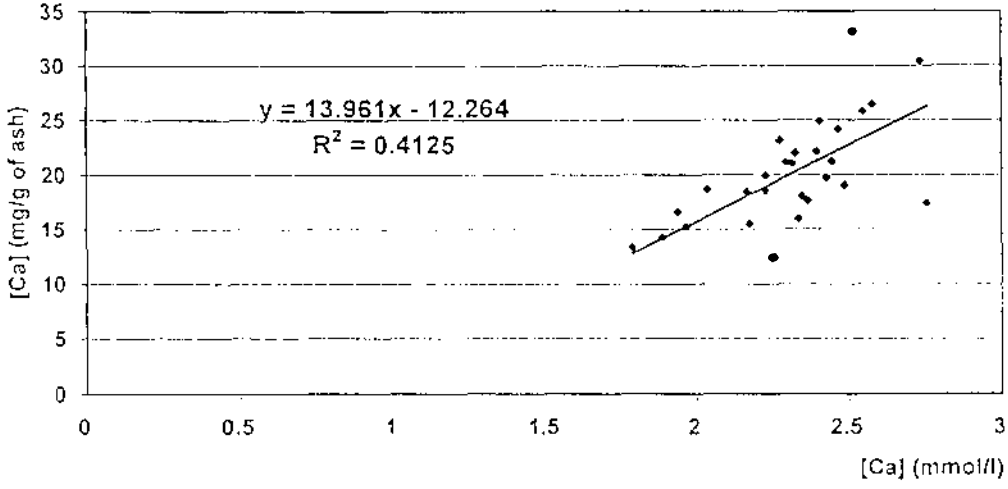
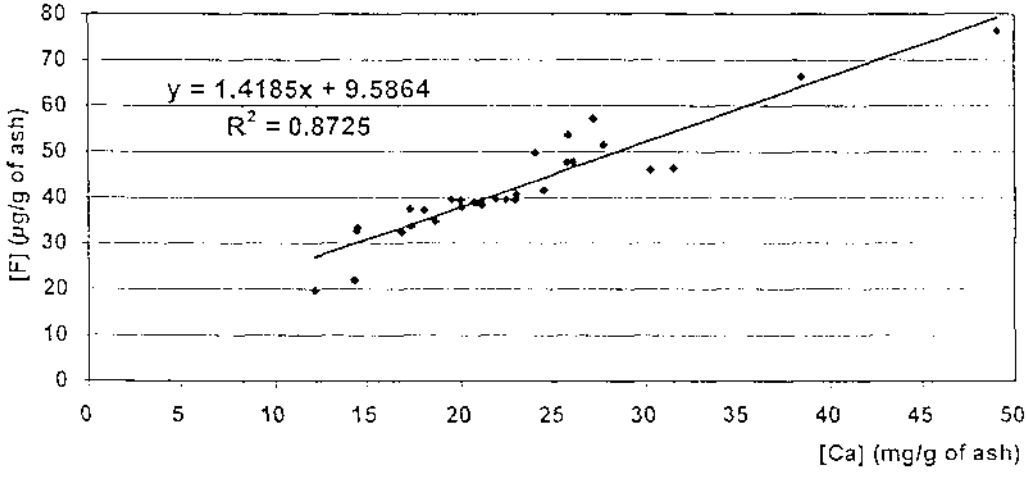


FIGURE 4. Correlation between fluoride and calcium concentrations in marginal part of placenta



DISCUSSION

In 1955, Feltman and Kosel[8] observed much higher concentrations of fluoride in peripheral regions (in comparison with central ones) of two examined placentas. These authors suggested that this differentiation was closely related to the calcium content of these parts of tissue. These findings were discussed in more recent studies by Shen and Taves,[6] who showed that fluoride accumulation in placenta may be connected with local focuses of calcification. Other studies by Zamorska and Niwelinski[9] demonstrated that placentas from urban-industrial regions abounded in calcium fluoride deposits. These findings are supported by data of Jendryczko *et al*[10,11] and of Chlubek.[4]

In recent Chinese investigations of fluoride exposure and intelligence in children the effect of fluoride appears to occur at an early stage of development of the embryo when the differentiation of brain nerve cells is taking place and development is most rapid.[12] Furthermore, a higher concentration of fluoride has been found in embryonic brain tissue obtained from termination of pregnancy in areas where fluorosis due to coal burning was prevalent.[13,14] These observations refute the view that the placenta protects the fetus from fluoride.

Based on our results, we conclude that placenta can accumulate fluoride in healthy women who are exposed in pregnancy to relatively low fluoride concentrations in water and in air. The greatest amount of placental fluoride is stored in the marginal part of the organ presumably as a result of the higher concentration of calcium found in that area.

The present paper was prepared in the framework of the KBN research project 4 S405 021 06 and was presented and discussed at the XXIst World Conference of the International Society for Fluoride Research in Budapest (25-29 August, 1996).

REFERENCES

1 Ron M, Singer L, Menczel J, Kidroni G Fluoride concentration in amniotic fluid and fetal cord and maternal plasma *European Journal of Obstetrics, Gynecology, and Reproductive Biology 21* 213-218 1986.

2 Chlubek D, Mokrzynski S, Machoy Z, Samujlo D, Wegrzynowski J. Fluoride concentration in mother and in fetus. I. Placental transport of fluoride. *Ginekologia Polska 65* 611-615 1994. [In Polish]

3 Shimonovitz S, Patz D, Everhadani P, Singer L, Zacut D, Kidroni G, Ron M. Umbilical cord fluoride serum levels may not reflect fetal fluoride status. *Journal of Perinatal Medicine 23* 279-282 1995.

4 Chlubek D. Some aspects of prenatal fluoride metabolism in humans. Studies performed during the perinatal period. *Annales Academiae Medicae Stetinensis* (suppl 31). Habilitation thesis, Pomeranian Medical Academy, Szczecin 1996.

5 Gedalia I, Brzezinski A, Bercovici B, Lazarov E. Placental transfer of fluorine in the human fetus. *Proceedings of the Society for Experimental Biology and Medicine 106* 147-149 1961.

6 Shen YW, Taves DR. Fluoride concentrations in the human placenta and maternal and cord blood. *American Journal of Obstetrics and Gynecology 119* 205-207 1974.

7 Gardner DE, Smith FA, Hodge HC, Overton DE, Feltman R. The fluoride content of placental tissue as related to the fluoride content of drinking water. *Science 115* 208-209 1952.
8 Feltman R, Kosel G. Prenatal ingestion of fluorides and their transfer to the fetus. *Science 122* 560-561 1955.
9 Zamorska L, Niwelinski J. Some aspects of human reproduction in the contemporary ecological conditions of Cracow. *Folia Medica Cracoviensia 24* 203-209 1982/1983
10 Jendryczko A, Szpyrka G, Tomala J, Kossowski P, Kozowicz M. Fluorine concentration in human placenta, and birth weight and head circumference of a newborn. *Bromatologia i Chemia Toksykologiczna 26* 613-151993. [In Polish]
11 Jendryczko A, Tomala J, Szpyrka G, Kossowski P, Kozowicz M. Mineral components of the human placenta, birth weight and the infant head circumference. *Ginekologia Polska 66* 267-271 1995. [In Polish]
12 Li XS, Zhi JL, Gao RO. Effect of fluoride exposure on intelligence in children. *Fluoride 28* 189-192 1995.
13 He H, Chen ZS, Liu XM. The influence of fluoride on the human embryo. *Chinese Journal of Control of Epidemic Diseases 4* 136-137 1989.
14 Du L, Wan CW, Cao XM. The influence of chronic fluorosis on the development of the brain of the human embryo. *Journal of Fluorosis Research Communications 7* 138-141 1991.

Published by the International Society for Fluoride Research. Editorial Office:
81A Landscape Road, Mount Eden, Auckland 1004, New Zealand