soluble and particulate fraction of the liver, whereas the other two patients were deficient in such an activity. Partially purified- β -glucosidase from acute infantile Gaucher's liver exhibited no activity measured with glucocerebroside as a substrate whereas those from juvenile Gaucher's liver showed considerable activity. These results suggest the possibility that a new type of genetic heterogeneity may be involved in neuropathic Gaucher's disease.

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Liver pregnancy
newborn trace elements
placenta

Trace Elements (Zinc, Cobalt, Selenium, Rubidium, Bromine, Gold) in Human Placenta and Newborn Liver at Birth

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Summary

Concentrations of zinc, cobalt, selenium, rubidium, bromine, and gold have been determined by neutron activation analysis in 18 placental and 6 liver tissue samples at birth. Their respective mean concentrations $\pm$ standard deviations (parts per million) were 58 ± 10 , 0.060 ± 0.036 , 1.90 ± 0.41 , 14.0 ± 3.5 , $26.9 \pm$

14.3 , and 0.31 ± 0.14 in placenta, and 651 ± 257 , 0.156 ± 0.077 , 4.52 ± 1.96 , 9.2 ± 3.7 , 11.2 ± 4.1 , and 0.12 ± 0.06 in liver tissue. Thus, we observed that the mean concentrations of essential trace elements (zinc, cobalt, and selenium) were significantly higher in liver than in placenta, whereas the nonessential trace elements (rubidium, bromine, and gold) were found in significantly higher concentrations in placenta than in liver tissue.

Speculation

The observed difference in the distribution pattern of the studied trace elements in placenta and liver tissues should be extended to other essential and nonessential trace elements. It would also be interesting to study the distribution pattern of trace elements in various pathologic conditions of the fetus.

The concentration of trace elements in the human liver has been studied more extensively than in any other viscera. The levels of copper, chromium, zinc, manganese, cobalt, and iron in the liver in childhood have been reported by many authors (3, 8, 11, 12, 13, 14, 17). It was shown that copper and manganese accumulate in the mitochondria and zinc in the cytoplasm of the liver cells, mainly as metalloenzymes (2, 6, 15). Data referring to the concentrations of trace elements in the human placenta have been reported only for zinc, iron, copper, lead, and cadmium (1, 5, 10, 17). In the present investigation the concentrations of zinc (Zn), cobalt (Co), selenium (Se), rubidium (Rb), bromium (Br), and gold (Au) in the tissues of human placenta and liver at birth have been studied.

MATERIALS AND METHODS

Trace elements were determined in the tissues of 18 placentas taken at the time of birth, in the Alexandra Maternity Hospital. The placentas were selected randomly from women with normal pregnancies. Liver samples were also taken, within 24 hr after birth, from six other newborns who died soon after birth. The causes of death were hypoxia or intracranial hemorrhage caused by birth injury.

Placenta samples (7 × 7 cm) were cut from the center of the embryonic surface with a clean plastic knife. Then the samples were pressed strongly in order to squeeze out the remaining blood. The samples were placed in clean plastic bags and stored at -20°. The same procedure was followed for the liver samples.

The tissue samples were analyzed at the Demokritos Nuclear Research Center, Athens, by the neutron activation analysis method (4). Two grams of tissue were placed into preweighed bottles and dried at 100° for 20 hr. The dried samples were placed in quartz tubes. The concentrations (in micrograms per ml) of elements in the standard solutions were as follows: Zn,

50; Br, 5; Co, 5; Rb, 2; Se, 0.09; Au, 0.9. The tubes were heat sealed and irradiated for 20 hr in the swimming pool reactor, using the rotation system (thermal neutron flux, 2.2×10^{13} neutrons/cm²/sec).

After irradiation quartz tubes containing the samples and standards were crushed in liquid nitrogen and the contents of tubes were transferred into clean tubes. Irradiated samples and standards were counted for 1 hr in the germanium-lithium detector of a 4000-channel analyzer. In samples and standards the areas under the photopeak corresponding to γ -rays of ¹⁹⁸Au at 411 keV, of ⁸²Br at 776 keV, of ⁸⁶Rb at 1077 keV, of ⁶⁵Zn at 1115 keV, of ⁷⁵Se at 264 keV, and of ⁶⁰Co at 1173 keV and/or 1332 keV were compared. The data were processed by a CDC 3300 computer.

RESULTS

The individual as well as the mean values and standard deviations (parts per million in dry weight and micrograms per 100 g fresh tissue) of the studied trace elements in placenta and liver tissues are shown in Tables 1 and 2.

Eighteen placentas were from newborns with mean gestational age of 39.3 ± 4 weeks and mean birth weight of $3,373 \pm 898$ g. Mean gestational age and mean birth weight of the six dead newborns from whom liver tissue was taken were 39.5 ± 2.4 weeks and $3,480 \pm 649$ g, respectively. The differences between the two groups were not statistically significant ($p > 0.05$).

Table 1 and 2 show that concentration of the studied trace elements do not vary substantially with gestational age. Furthermore, no significant correlation ($p > 0.05$) was found between gestational age and the concentration of each one of the studied trace elements in placenta as well as in liver tissue.

Further analysis of our results separately for each studied trace element is as follows.

ZINC

The mean values of Zn concentrations in placenta and liver tissues were 58.1 ± 10.1 and 651 ± 257 ppm, respectively. Thus, the concentration of Zn in liver tissue was 11-fold higher than that in placenta. The difference was statistically very significant ($t = 10.23$; $P < 0.001$).

Table 1. Individual (parts per million of dry matter) and mean values $\pm$ SD of trace element concentrations in placenta tissue

No.	Gestational age (weeks)	Zn	Co	Se	Br	Rb	Au
1	29	60.8	0.050	1.68	8.3	12.0	0.27
2	30	53.5	0.070	1.24	31.7	17.5	0.17
3	38	77.8	0.130	2.67	52.5	12.7	0.49
4	38	51.0	0.054	1.73	41.2	19.0	0.24
5	39	66.3	0.040	1.86	13.7	11.1	0.50
6	39	46.5	0.090	1.25	12.6	13.3	0.26
7	40	61.0	0.020	2.38	32.5	19.6	0.22
8	40	54.0	0.025	1.72	24.8	12.7	0.24
9	40	60.7	0.140	2.37	13.6	15.8	0.21
10	40	58.5	0.050	1.62	10.9	7.7	0.41
11	40	55.1	0.036	1	52.7	7.8	0.35
12	41	57.3	0.110	2.31	27.5	18.1	0.56
13	41	77.7	0.040	2.13	22.3	12.0	0.12
14	42	47.6	0.037	1.66	26.3	17.7	0.14
15	42	48.5	0.072	2.13	47.0	14.8	0.48
16	43	41.1	0.030	1.64	17.2	14.2	0.34
17	43	70.0	0.070	2.32	21.7	12.7	0.26
18	44	58.9	0.020	1.65	1	13.9	1
Mean $\pm$ SD (ppm dry matter)		58 $\pm$ 10	0.060 $\pm$ 0.036	1.90 $\pm$ 0.41	26.9 $\pm$ 14.3	14.0 $\pm$ 3.5	0.31 $\pm$ 0.14
Mean $\pm$ SD (μ /100 g fresh tissue)		994 $\pm$ 239	1.04 $\pm$ 0.65	33 $\pm$ 7.10	522 $\pm$ 283	250 $\pm$ 69	5.45 $\pm$ 2.60

¹ Missing sample.

Table 2. Individual (parts per million of dry matter) and mean values $\pm$ S D of trace element concentrations in liver tissue

No.	Gestational age (weeks)	Zn	Co	Se	Br	Rb	Au
1	37	798	0.30	4.79	12.4	9.2	0.13
2	37	436	0.09	3.38	7.8	4.7	0.06
3	38	784	0.15	2.53	8.7	13.5	0.21
4	41	405	0.09	5.81	9.3	5.4	0.08
5	42	1,032	0.17	7.65	18.8	13.3	0.17
6	42	452	0.14	2.93	10.0	8.9	0.07
Mean $\pm$ SD (ppm dry matter)		651 $\pm$ 257	0.156 $\pm$ 0.077	4.52 $\pm$ 1.96	11.2 $\pm$ 4.1	9.2 $\pm$ 3.7	0.12 $\pm$ 0.06
Mean $\pm$ SD (μ g/100 g fresh tissue)		14,334 $\pm$ 6,004	3.44 $\pm$ 1.91	99 $\pm$ 40.2	240 $\pm$ 89	199 $\pm$ 83	2.5 $\pm$ 1.33

COBALT

The mean concentration of Co in liver tissue (0.156 ± 0.077 ppm) was 2-fold higher than that in placenta (0.060 ± 0.036 ppm). The difference was found to be statistically highly significant ($t = 4.19$; $P < 0.001$).

SELENIUM

The mean values of Se concentration in placenta and liver tissues were 1.90 ± 0.41 and 4.52 ± 1.96 ppm, respectively. Thus, the Se concentration in liver tissue was 2-fold higher than that in placenta. The difference was statistically significant ($t = 3.14$; $P < 0.01$).

BROMIUM

The mean concentration of Br in placenta (26.9 ± 14.3 ppm) was 2-fold higher than that in liver tissue (11.2 ± 4.1 ppm). The difference was statistically significant ($t = 2.60$; $P < 0.02$).

RUBIDIUM

The mean concentrations of Rb in placenta and liver tissues were 14.0 ± 3.5 and 9.2 ± 3.7 ppm, respectively. The level of Rb was higher in placenta than in liver tissue. The difference was statistically significant ($t = 2.92$; $P < 0.01$).

GOLD

Gold mean concentration was found also to be significantly higher ($t = 3.28$; $P < 0.01$) in placenta (0.31 ± 0.14 ppm) than in liver tissue (0.12 ± 0.06 ppm). Thus, the level of Au in placenta was 3-fold higher than that in liver tissue.

DISCUSSION

Widdowson and Spray (17) found a mean Zn concentration in placenta tissue of approximately 1 mg/100 g fresh tissue, which is comparable to our values (994 μ g/100 g fresh tissue).

Zn and Co concentrations in the liver were reported by many authors (13, 16, 17). In the present investigation the Zn and Co mean liver concentrations, 14.3 mg/100 g and 3.44 μ g/100 g fresh tissue, respectively, were found to be lower than those reported by Widdowson *et al.* (16).

The distribution of trace elements in the human body has been considered as a method of determining whether an element is essential or nonessential (7, 9). We found that the amounts of essential trace elements as Zn, Co, and Se were significantly higher in liver than in placenta. On the other hand, the nonessential trace elements as Br, Rb, and Au have been found in higher concentrations in placenta than in liver tissue. Thus, although the studied sample is not large enough to draw final conclusions, we believe that our observation on the distribution pattern of trace elements in placenta and liver tissues is another

example of the difference in distribution of essential and nonessential elements.

CONCLUSION

The concentrations of trace elements (Zn, Co, Se, Br, Rb, and Au) in the placenta and liver tissues were determined by neutron activation analysis. Essential trace elements such as Zn, Co, and Se were found in significantly higher concentrations in liver than in placenta, whereas levels of nonessentials such as Br, Rb, and Au were higher in placenta than in liver tissue. Our observation on the distribution pattern of trace elements in placenta and liver tissues is another example of the difference in distribution of essential and nonessential elements.

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