Objective. To estimate thyroid volume (ThV) in primiparous (PP) and multiparous (MP) mothers (MO) and their newborns (NB) as related to their urinary iodine and thus contribute to the question on the interrelation between iodine intake during the pregnancy and thyroid function in pregnant women.

Methods. The ThV by ultrasound was estimated in a total of 258 MO (108 PP and 150 MP) and their newborns on the 4th-7th day after delivery. There were 227 in term and 31 preterm (before 37th week) deliveries. In addition, ThV was estimated in double amount of controls (216 vs. PP and 300 vs. MP) in the same age range and nearly age matched which were either nulliparous or did not have delivery within last 12 months.

Urinary iodine concentration was estimated in spot urine samples obtained from 75 MO and their NB and milk iodine in 44 milk samples obtained between the 4th and 7th day after delivery.

Results. On the first week after delivery, the ThV in all 258 MO was significantly higher than that in 516 of nearly age matched females (mean–S.D.: 14.87±4.93 ml vs. 10.61±4.02 ml, resp., P<0.01). Although the ThV was lower in 108 PP than in 150 MP women (mean–S.D.: 13.85±4.51 ml vs. 15.59±5.11 ml, resp., P<0.01), it was still significantly higher (P<0.01) than that in a double amount of nearly age matched controls for PP (9.96±3.15 ml) and MP (11.07±4.48 ml).

Mean ThV found in all 258 NB was 0.60±0.21 ml (median 0.5 ml, range 0.2-1.6 ml), the values in those born in term being higher than in preterm (mean–S.D. 0.62±0.20 ml vs. 0.45±0.12 ml; P<0.01). No correlation was found between the ThV and body weight in NB. However, significant correlation was found between the ThV in all 257 NO and their NB (r=0.292, P<0.05).

The mean value of urinary iodine in mothers on the first week after delivery was 9.0±7.2 µg/dl (median 6.1, range 3.0-47.2). The average urinary iodine in primiparous was slightly higher than that in multiparous mothers (10.3 vs. 8.4 µg/dl; not significant). In newborns, the mean urinary iodine in the first week after birth was 11.6±7.6 µg/dl (median 6.5, range 0.7-45.0).

Conclusions. The finding of about 30 % higher ThV in 258 mothers after delivery than that in double amount of nearly age matched women (P<0.01) who were either nulliparous or did not have delivery at least within last 12 months shows that, in spite of general satisfactory iodine intake in Slovak population, the iodine intake during pregnancy was not satisfactory. This is supported by the data on urinary iodine which was higher in primiparous than in multiparous women.

Key words: Thyroid volume – Ultrasound – Mothers – Newborns –Urinary iodine – Human milk iodine
crease of chorionic gonadotropin and estrogens, but also by the production of thyroid hormones which depends on the intake of iodine the need for which is increasing (GLINOER et al. 1990, 1992 a,b, 1993, 1996, 1997).

The synthesis of thyroid hormones in fetal thyroid starts from about 20th week of gestation. These hormones together with the transplacental transfer of maternal thyroxine play decisive role in the fetal growth and differentiation. The fetal thyroid needs about 25 µg iodine per day (GLINOER et al. 1992; BOEHLES et al. 1993) which comes from the maternal blood via the placenta. Such loss of iodide plus the increased renal iodide clearance result at least in a relative iodine deficiency in the mother. In the second and third trimester the level of TSH in the mother is increasing and even the relative iodine deficiency results in increasing sensitivity of her thyroid to the TSH, the growth effect of which may appear even at the high normal blood level (GLINOER et al. 1994; GLINOER 1997).

The function of fetal thyroid is entirely dependent on the iodide supply from the mother and on the functional status of her thyroid. The development of neonatal goiter from intrauterine iodine deficiency is prevented by sufficient prenatal iodine intake which should result in neonatal ioduria higher than 5 µg/dl (DELANGE and BUEHRIG 1989), while more severe deficiency results in the impaired maturation of central nervous system.

Iodine intake in Slovakia during the last about 45 years may be considered satisfactory as supported namely by the recent European Thromobil Study (DELANGE et al. 1997). From this appears that any serious disorders of central nervous system cannot be expected. However, even under the satisfactory iodine intake some relative iodine deficiency during the pregnancy may appear which may result in the increase of thyroid volume in both the mother and newborn. The aim of this study was to contribute to this question.

**Subjects and Methods**

**Subjects.** A total of 258 mothers and their newborns were examined on the 4th-7th day after delivery. Among the mothers 108 were primiparous (mean age 22.5 years, range 17-34) and 150 multiparous (mean age 28.2 years, range 17-44). There were 227 in term and 31 preterm (before 37th week) deliveries. In addition, thyroid volume was estimated in double amount of controls (216 vs. primiparous and 300 vs. multiparous women) in the same age range and nearly age matched which were either nulliparous or did not have delivery within last 12 months.

**Thyroid volume.** Thyroid examination was performed by a real-time instrument (ALOCA SSD 630, Japan) using a 7.5 mHz linear transducer. ThV for each lobe (ml) was calculated according to the ellipsoid formula: width cm x length cm x thickness cm x correction factor of 0.479 (BRUNO et al. 1981). In newborns, the thyroid volume was measured according to Simpson, the apparatus used being equipped with the appropriate software (Fig. 1).

**Urinary iodine.** The estimation of urinary iodine concentration was performed in spot urine samples obtained from 75 mothers and their newborns. The aliquots of 250 µl urine were digested in thermoblock at 110-115 °C with 750 µl perchloric acid for 60 min. For final evaluation, Sandell-Kolthoff reaction under temperature and time control was used followed by spectrophotometry at 410 nm. The results were expressed in terms of µg/dl.

**Iodine in human milk.** In 44 mothers the concentration of iodine in milk samples obtained between the 4th and 7th day after delivery was estimated using dry-ash alkaline digestion in muffle oven at 420 °C followed by Sandell-Kolthoff reaction as described above. The results were expressed in terms of µg/dl.

**Statistical evaluation.** Students t-test for unpaired values, regression analysis and one way ANOVA were used.

**Results**

**Thyroid volume in mothers.** On the first week after delivery, the thyroid volume in all mothers (N=258) was significantly higher than that in 516 of nearly age matched females of the same age range who either were not yet pregnant at all or did not have delivery within the last 12 months (mean±S.D.: 14.87±4.93 ml vs. 10.61±4.02 ml, resp., P<0.01). Although the thyroid volume was lower in primiparous (N=108) than in multiparous (N=150) women (mean±S.D.: 13.85±4.51 ml vs. 15.59±5.11 ml, resp., P<0.01), it was still significantly higher (P<0.01) than
that in a double amount of nearly age matched controls for primiparous (9.96±3.15 ml) and for multiparous (11.07±4.48 ml) women (Fig. 2).

In a total of 26/258 (10.1 %) mothers the thyroid volume was >22.0 ml which, in pregnant women, is considered as goiter (GLINOER et al. 1996). Such in-

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**Fig. 1**
Method of thyroid volume estimation in newborns according to Simpson. The circles show individual lobes of the thyroid as located on both sides of the larynx.

**Fig. 2**
Thyroid volume in primiparous (N= 107) and multiparous (N=151) mothers (black columns) and the double number of nearly age matched control women (C - white columns) who were either nulliparous or did not have delivery within last 12 months. Means and S.E. ** = P<0.01 vs. appropriate control.
crease was more frequent (P<0.05) in multiparous (20/150, 13.6 %) than in primiparous women (6/108, 5.6 %). In contrast, significantly higher frequency of smaller thyroids (<18.0 ml) was found in primiparous (93/108; 86.1 %) than in multiparous women (101/150; 67.3 %; P<0.001).

**Thyroid volume in newborns.** Mean thyroid volume found in all 258 newborns was 0.60±0.21 ml (median 0.5 ml, range 0.2-1.6 ml), the values in those born in term being higher than in preterms (mean±S.D. 0.62±0.20 ml vs. 0.45±0.12 ml; P<0.01; Fig. 3). The volume >1.0 ml was found in 16 newborns (6.2 %) and that >1.3 ml in 4 of them.

The thyroid volume <1.0 ml was found in 242 (93.8 %) and that in the range of 0.2-0.5 ml was found in 120 newborns. The frequency of small thyroid volumes (e.g. between 0.2 and 0.5 ml) was about the same in primiparous (51/108; 47.2 %) and multiparous women (69/150, 46.0 %), while the frequency of very small volumes (e.g. 0.2 to 0.3 ml) was higher in primiparous (24/108, 22.2 % vs. 20/150, 13.3 %, P<0.05, resp.). The frequency of the volumes >1.0 ml in multiparous women (11/150; 7.3 %) was about the same as in primiparous (5/108, 4.6 %).

No correlation was found between the thyroid volume and body weight in newborns. However, significant correlation was found between the thyroid volume in the mothers and their newborns (r=0.292, P<0.01).

**Urinary iodine in mothers.** The mean value of urinary iodine in mothers on the first week after delivery was 9.0±7.2 µg/dl (median 6.1; range 3.0-47.2). There was no difference between primiparous and multiparous mothers, although the excretion in primiparous ones was slightly higher (the mean of 10.3 vs. 8.4 µg/dl). In addition, there was no difference in urinary iodine between the mothers who had delivery in term and those who had it preterm (median 6.3 vs. 5.9 µg/dl). There was no correlation between urinary iodine in mothers and their thyroid volume.

**Urinary iodine in newborns.** In newborns, the mean urinary iodine in the first week after birth was 11.6±7.6 µg/dl (median 6.5; range 0.7-45.0). The median in these born in term was 6.6 µg/dl and that in preterms was 5.5 mg/dl. Significant correlation (r= 0.372, P<0.01) was found between urinary iodine in mothers and their newborns. Similarly as in
mothers, the mean values of urinary iodine in newborns of primiparous were higher (not significantly) than those in newborns of multiparous mothers (13.1 vs. 10.3 $\mu$g/dl). There was no correlation found between thyroid volume and urinary iodine in newborns.

**Iodine in mother milk.** The mean level of iodine in mother milk was 8.9–14.1 $\mu$g/dl (media 5.5, range 4.3-75.1). It was observed that these after Caesarean section had higher values. The average value in primiparous was unsignificantly higher than that in multiparous (10.5 vs. 8.1 $\mu$g/dl), while median was the same (5.5 $\mu$g/dl).

### Discussion

In this cross-sectional study the thyroid volume found in 258 mothers 3-5 days after delivery was about 30 % higher than that in double amount of nearly age matched women who were either nulliparous or did not have delivery at least within last 12 months. In this respect the findings are comparable with longitudinal ultrasound studies in Denmark (RASMUSSEN et al. 1989; PEDERSEN et al. 1993), Belgium (GLINOER et al. 1990, 1995), Ireland (SMYTH et al. 1991) and Italy (ROMANO et al. 1991), while in Netherlands BERGHOUT et al. (1994) did not find any increased volume in ten longitudinally followed pregnant women (Tab. 1). Among these countries, the iodine intake in Netherlands is considered sufficient, while that in the other countries (Belgium, Denmark, Italy and Ireland) is considered moderate or low. Thus, the difference between no increase in thyroid volume in Netherlands vs. increase in other countries is explained by the different iodine intake, e.g. sufficient in Netherlands and insufficient in the other countries. This explanation may be challenged by the findings in Germany by LISENKOETTER et al. (1996) who were not able to prevent an increase of maternal thyroid gland volumes during pregnancy even by the daily administration of 300 $\mu$g potassium iodide.

Since the recent study of thyroid volume and urinary iodine in adolescents from 12 European countries showed the lowest thyroid volume and highest

### Table 1

<table>
<thead>
<tr>
<th>Authors</th>
<th>Country</th>
<th>N</th>
<th>Thyroid volume (ml) Mean ± S.D.</th>
<th>Thyroid volume &gt;22.0</th>
<th>Urinary iodine</th>
</tr>
</thead>
<tbody>
<tr>
<td>RASMUSSEN et al. (1989)</td>
<td>Denmark</td>
<td>20</td>
<td>24.1 ± 2.2</td>
<td>30 %</td>
<td>not indicated</td>
</tr>
<tr>
<td>BRANDER et al. (1989)</td>
<td>Finland</td>
<td>21</td>
<td>13.7 ± 2.3</td>
<td></td>
<td>not estimated</td>
</tr>
<tr>
<td>ROMANO et al. (1991)</td>
<td>Italy</td>
<td>18</td>
<td>11.8 ± 1.3 (untreated)</td>
<td></td>
<td>mean 37.0 $\mu$g/24h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17</td>
<td>10.1 ± 1.1 (treated)</td>
<td></td>
<td>mean 30.5 $\mu$g/24h</td>
</tr>
<tr>
<td>GLINOER et al. (1990)</td>
<td>Belgium</td>
<td>179</td>
<td>15.0 ± 6.8</td>
<td></td>
<td>median 45 $\mu$g/l</td>
</tr>
<tr>
<td>BOHLES et al (1993)</td>
<td>Germany</td>
<td>61</td>
<td>14.4 (range 4.5-66.8)</td>
<td></td>
<td>58 $\mu$g/g Cr</td>
</tr>
<tr>
<td>PEDERSEN et al. (1993)</td>
<td>Denmark</td>
<td>56</td>
<td>about 12.4</td>
<td></td>
<td>53 $\mu$g/l</td>
</tr>
<tr>
<td>BERGHOUT et al. (1994)</td>
<td>Netherlands</td>
<td>10</td>
<td>9.4 ± 3.0</td>
<td></td>
<td>not shown</td>
</tr>
<tr>
<td>LISENKOETTER et al. (1996)</td>
<td>Germany</td>
<td>38</td>
<td>20.1 ± 9.0 (treated)</td>
<td></td>
<td>104.5 $\mu$g/g Cr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>70</td>
<td>20.0 ± 11.0 (untreated)</td>
<td></td>
<td>54.9 $\mu$g/g Cr</td>
</tr>
<tr>
<td>HNIKOV A et al (1996)</td>
<td>Czech Rep.</td>
<td>50</td>
<td>mean 12.0 (treated)</td>
<td></td>
<td>62 $\mu$g/l</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>mean 14.3 (untreated)</td>
<td></td>
<td>43 $\mu$g/l</td>
</tr>
<tr>
<td>SMYTH et al. (1997)</td>
<td>Ireland</td>
<td>115</td>
<td>16.0 ± 0.7</td>
<td></td>
<td>76 ± 5.7 $\mu$g/l</td>
</tr>
<tr>
<td>TAJTAKOV A et al. (this study)</td>
<td>Slovakia</td>
<td>258</td>
<td>14.9 ± 4.9</td>
<td>10 %</td>
<td>mean 83 $\mu$g/l</td>
</tr>
</tbody>
</table>
Thyroid volume in newborns found in this study was similar to that reported by several authors (Tab. 2). This is true namely for the lower limit of the range (e.g. 0.2-0.3 ml), while the mean values and upper limits appear to differ according to iodine intake and urinary iodine. Thus, in newborns of iodine supplemented mothers the upper limit was 1.4 ml (GLINOER et al. 1994) and 1.6 ml (LIESENKOETTER et al. 1995) compared to 1.6 ml in this study, while the respective means were 0.7, 0.7 and 0.6 ml. However, in the newborns of unsupplemented mothers the upper limit was 2.5 ml (GLINOER et al. 1994) and 2.6 ml (LIESENKOETTER et al. 1995) and respective means were 1.05 and 1.5 ml which was definitely higher than the values found in this study.

Thyroid volume higher than 1.3 ml was found in 16 newborns. However, the frequency of such thyroid volume in newborns of multiparous mothers was higher (11/16) than that in primiparous ones (5/16) and, similarly, the thyroid volume higher than 2.0 ml was more frequent in multiparous (20/26) than in primiparous ones (6/26). This finding might result from repeated pregnancies in multiparous women who were thus even repeatedly exposed to relative iodine deficiency. If so, it may be suggested that namely such women should be supplemented by small doses of iodide.

References


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