Parenteral magnesium load tests in postpartum American women1, 2

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ABSTRACT The magnesium status of 185 moderate income American mothers was assessed in the immediate postpartum period by the intravenous magnesium load test. Pre- and postload collections of urine were each made for approximately 24 hours because pilot studies revealed significant diurnal variation in magnesium excretion. The magnesium load provided 0.4 to 0.5 mEq of magnesium/kg of estimated lean body weight. The mean retention was 51% ± 2.2 (SEM). Patients retaining more or less than an arbitrary limit of 40% of the magnesium load were compared. No differences in mean age, weight, or parity were found between the groups. The high retention group reported a diet lower in magnesium and had a significantly lower plasma magnesium value. Magnesium retention of over 90% of the load was found in biologically immature multiparas (less than 17 years) and in young mothers of twins. Among the multiparous patients, those with the longest interval since the previous pregnancy had the lowest retention values. Most of the primiparous patients had met the magnesium requirements of a singleton pregnancy and rejected most of the load, but 6 primiparous women whose active labor exceeded 18 hours had a retention of 77.91% of the load. This was significantly higher than the 45.0 ± 3.52 (SEM) % retention in 70 primiparous mothers with shorter duration of active labor (P < 0.005). No other symptoms or complications of pregnancy could be correlated with the magnesium load values. Further definition of the magnesium load test is indicated. Am. J. Clin. Nutr. 28: 1099-1104, 1975.

An increase in magnesium requirements during human gestation has been appreciated from balance studies (1) and from the increasing concentration of magnesium in fetal tissue as it approaches term (1, 2). It is not known how well the additional requirements of pregnancy are met. This study surveyed the magnesium status of urban American women of low- to moderate income in the immediate postpartum period chiefly by means of the parenteral magnesium load test.

Materials and methods

This study was conducted during 1973 on the St. Louis University Obstetrics Service of the St. Louis City Hospital (Max Starkloff Memorial Hospital) and on the St. Louis and Washington University Obstetrics Services of the St. Louis County Hospital.

Within 1 day of delivery, the hospital records of patients were reviewed and patients with no renal or other medical problems that would contraindicate the test were interviewed, particularly in regard to adequacy of economic support; their diets, including intake of magnesium-rich foods such as whole grain products and legumes; and their past medical and obstetric histories. The magnesium load test was explained and informed consent obtained.

To quantitate the diurnal pattern of magnesium excretion, 24-hour collections of urine were obtained from 13 patients at 8-hourly intervals beginning at 8 AM, analyzed for magnesium content, and the excretion values during the three periods were compared by the analysis of variance.

For the loading tests, a timed preload collection was made for about 24 hours. In about 70% of the patients, blood was drawn for magnesium determination. The magnesium load was given intravenously over a 45-min period in a dose of 20 or 24 mEq of magnesium as diluted magnesium sulfate heptahydrate to provide a dose of 0.4-0.5 mEq of magnesium/kg of lean body weight. Timed postload collections of urine were made for approximately 24 hours; the minimum collection time was 16 hours. Urine was analyzed for magnesium, calcium, sodium, and potassium on an atomic absorption spectrophotometer using 1% lanthanum as a blank and diluent, and normal urine standards. The percentage of

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the magnesium load retained was calculated from the data from the base period and the net excretion after the load. Comparisons of pre- and postload excretions of the other cations were made after correcting each excretion period to 24 hours.

Using 40% retention of the magnesium load as the arbitrary upper limit of normal, comparison was made between patients with retention levels above and below this level. Next, retention values were compared according to age and parity. Appropriate statistical analyses were made using the analysis of variance, Student's t-test, and the chi-square test.

Results

The patients

Data from 198 patients are included in this report: 13 made three 8-hourly collections of urine and 185 successfully completed the magnesium load test. Of these, 98 were black and 87 were white. These patients were not truly representative of the two hospital populations, since some patients with superior nutritional histories did not participate in the test.

Individual values of magnesium retention are shown in Fig. 1. The mean retention was 51.0% ± 2.2 SEM. Comparisons (Table 1) were made between patients who retained more or less than the arbitrarily set value of 40%. There were 60 patients in the low retention group, 42 black and 27 whites, and 116 patients in the high retention group, 56 blacks and 60 whites. About 50% of the patients were married. Data from patients with high and low magnesium retention were examined statistically by the analysis of variance; no significant differences were found between age, gravidity, or body weight. Grouped patients with higher retention of magnesium had a poorer rating for quality of diet, which usually consisted of inexpensive foods poor in protein, magnesium, and other nutrients: fried potatoes, milled starches, and fatty meats. The mean plasma magnesium value and the preload urine magnesium level were both significantly lower in the patients who retained more of the magnesium load. On an individual basis, the plasma magnesium was an unreliable guide to the magnesium status of the patient; only plasma magnesium values below 1.2 mEq/liter could be matched with high retention of magnesium.

Effect of gravidity, age, spacing, and multiple births on magnesium retention

Data presented in Table 2 were examined by Student's t-test to learn the effect of various factors on the magnesium retention. Multiparous women less than 17 years of age, and therefore probably biologically immature, retained 90% of the load, significantly more than their primiparous age peers (P < 0.001) (Fig. 2a).

Comparisons were made between multiparous women from 17 to 30 years of age and those over 30 years. The younger women had a shorter interval since the previous pregnancy (1.90 ± 0.11 years) compared with older women (3.44 ± 0.75 years) (P < 0.01), and they retained about 25% more of the magnesium load (P < 0.005) than did the older women. Four mothers of twins between 17 and 30 years retained 97% of the load, significantly greater retention than their age peers who bore singletons (P < 0.005; Fig. 2b).

<table>
<thead>
<tr>
<th>Retention of load</th>
<th>Percent retention</th>
<th>Age, years</th>
<th>Gravidity</th>
<th>Body weight, kg</th>
<th>Quality of diet&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Plasma magnesium, mEq/liter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 40% N = 69</td>
<td>18.6 ± 1.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>21.6 ± 0.7</td>
<td>2.5 ± 0.2</td>
<td>60.9 ± 1.4</td>
<td>2.37 ± 0.07</td>
<td>1.58 ± 0.037 (46)</td>
</tr>
<tr>
<td>More than 40% N = 116</td>
<td>70.1 ± 1.7</td>
<td>20.7 ± 0.4</td>
<td>2.5 ± 0.1</td>
<td>59.0 ± 1.0</td>
<td>1.83 ± 0.05</td>
<td>1.45 ± 0.025 (81)</td>
</tr>
</tbody>
</table>

Statistical significance P < 0.001 NS<sup>c</sup> NS NS P < 0.001 P < 0.001

<sup>a</sup> Mean ± standard error of the mean. <sup>b</sup> Diet assessed: 1 = poor, 2 = good, 3 = good, particularly in terms of magnesium-rich foods. <sup>c</sup> NS = not statistically significant.

TABLE 1
Comparison of postpartum patients with low and high retention of magnesium
PARENTERAL MAGNESIUM LOAD TESTS

![Graph](image)

**FIG. 1.** Each point represents the percent retention of the magnesium load in a postpartum woman. The mean percent retention for the 185 patients studied, 51.0 ± 2.2 SEM, is shown by a bar.

Incidence of symptoms and complications

Neither subjective findings (dizziness, numbness of extremities, muscle cramps, nervousness, or pounding heart) nor finding of peripheral edema with or without hypertension could be related to the percent retention of the magnesium load. A chi-square (two by two contingency) test failed to show a relationship between diet and the complications of pregnancy: prematurity, stillbirths, and abortions. However, 6 primiparous women with prolonged active labors (over 18 hours) had a percent retention of 77.91 ± 7.82 SEM of the load; this was significantly higher than the percent retention of 45.03 ± 3.52 SEM found in 70 primiparous mothers with shorter duration of active labor (P < 0.005). No such conclusion was found from a similar comparison of multiparous women. Many patients reported that they felt more comfortable and relaxed following the load; a blind trial would be required to assess these subjective observations.

**Preload magnesium excretion**

Analysis of variance revealed a significant difference between the magnesium excretion during three 8-hour preload periods (P < 0.001); therefore, the preload collection was made for 24 hours.

Comparison of 24-hour preload magnesium excretion in mothers with high and low excretion revealed a lower baseline excretion in the high retention group: values in mEq ± SEM were 4.01 ± 0.26 versus 6.01 ± 0.46 (P < 0.005).

**Postload cation excretion**

Comparison of 24-hour pre- and postload excretion of calcium, potassium, and sodium revealed a modest but significant increase only in calcium excretion (P < 0.01).

**Discussion**

**Blood magnesium values**

Several investigators have noted decreased plasma or erythrocyte magnesium values in asymptomatic patients in late pregnancy or in the puerperium (3-5). Physiologic hemodilution (5) contributes to the low plasma magnesium value; the low erythrocyte magnesium value might indicate an occult magnesium depletion (4).

**Magnesium load test**

Control data were provided by the best nourished postpartum women of the present series and of well-nourished Thai women in a previous series (3). In the present study, women of higher economic status, many of whom were studied at the St. Louis County...
TABLE 2
Effect of age, gravidity, and twinning on magnesium retention

<table>
<thead>
<tr>
<th>Women being compared</th>
<th>Percent retention</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group 1 vs. Group 2</td>
<td></td>
</tr>
<tr>
<td>I: Primips under 17 years</td>
<td>47.2 ± 4.6</td>
<td>90.5 ± 7.6</td>
</tr>
<tr>
<td>II: Multips under 17 years</td>
<td>(23)</td>
<td>(3)</td>
</tr>
<tr>
<td>I: Primips under 17 years</td>
<td>47.2 ± 4.6</td>
<td>45.5 ± 4.1</td>
</tr>
<tr>
<td>II: Primips 17 to 30 years</td>
<td>(23)</td>
<td>(59)</td>
</tr>
<tr>
<td>I: Primips 17 to 30 years</td>
<td>45.5 ± 4.1</td>
<td>58.4 ± 3.3</td>
</tr>
<tr>
<td>II: Multips 17 to 30 years</td>
<td>(59)</td>
<td>(80)</td>
</tr>
<tr>
<td>I: Multips under 17 years</td>
<td>90.5 ± 7.6</td>
<td>58.4 ± 3.3</td>
</tr>
<tr>
<td>II: Multips 17 to 30 years</td>
<td>(3)</td>
<td>(80)</td>
</tr>
<tr>
<td>I: Multips 17 to 30 years</td>
<td>58.4 ± 3.3</td>
<td>32.2 ± 5.8</td>
</tr>
<tr>
<td>II: Multips 30 or more years</td>
<td>(80)</td>
<td>(18)</td>
</tr>
<tr>
<td>I: Mothers of twins</td>
<td>96.6 ± 1.6</td>
<td>56.9 ± 3.3</td>
</tr>
<tr>
<td>17 to 30 years</td>
<td>(4)</td>
<td>(76)</td>
</tr>
<tr>
<td>II: Mothers of singletons</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Mean ± standard error of the mean.  * Numbers in parentheses indicate the number making up the mean.  * NS = not statistically significant.

![Image](https://academic.oup.com/ajcn/article-abstract/28/10/1099/4716632)

FIG. 2. Each point represents the percent retention of the magnesium load in a) biologically immature para 2, gravida 2 women and b) mothers less than 30 years of age who had just borne twins.

Hospital, usually received a more nutritious, magnesium-rich diet that included legumes and other fresh vegetables and whole grain products (6). In the Thai study, nine nulliparous women retained a mean of 22.6% of the load and, despite age and parity, most of the postpartum patients retained less than 40% of the load; 37% of them retained a mean of 9% of the load. These studies indicate that the requirements of pregnancy can be met by adequate dietary magnesium.

The parenteral magnesium load test is meaningful only in patients with normal renal function. During deficiency a normal kidney maintains normal renal concentration ability (7) and avidly retains magnesium, while the subject in magnesium balance promptly excretes surplus magnesium (8–10). Massry and associates (11) demonstrated a maximum tubular reabsorptive capacity for magnesium; renal excretion rose steeply as the diffusible fraction of serum magnesium increased to 5.8 mEq/liter.

Harris and Wilkinson (8) warned that even severely deficient patients would excrete a rapidly infused magnesium load. The present load increases the serum magnesium concentration less than 1 mEq/liter (3); the fact that some patients retained 100% of the load indicates that there was no obligatory renal excretion.

Magnesium load test in adults

The magnesium load test has not been precisely defined; the design of the present
study was based on guidelines set by earlier investigators. It is not certain from the published reports that all investigators have accounted for the baseline excretion; failure to do so could result in an error of 10–20% of the magnesium retention. Barnes and associates (12) correlated magnesium deficiency in an adult with retention of more than 30% of a 30–40 mEq load of magnesium given intramuscularly or intravenously over 1 hour. Thorén (10) gave 20 mEq of magnesium intramuscularly in two divided doses in adults and noted that magnesium-deficient patients retained 40–80% of the load.

The dose used in this study, 20–24 mEq of magnesium, approximates 0.4–0.5 mEq/kg of estimated lean body weight, given at the rate suggested by Barnes (12). High retention of a single load of this dose indicates that the patient had failed to meet the magnesium requirements of pregnancy, but does not quantitate the deficiency; a series of loads would be required to define the extent of the depletion (10).

**Magnesium retention in the present study**

Significant differences were found in the mean retention of magnesium loads in various groups. The primiparous patients reported here could usually meet the magnesium requirements of a singleton pregnancy. High retention was found in biologically immature multiparous patients, probably because of competition for limited amounts of essential nutrients required for growth by both mother and fetus, as described by Warkany (13). High retention was also found in mothers 17 to 30 years of age following twin pregnancies. The superior magnesium balance of the oldest patients who had the longest interval since the previous pregnancies might indicate that these patients had adequate time for repletion of essential nutrients, including magnesium.

The high retention of magnesium in the group of primiparous women with prolonged active labor is worthy of further investigation in view of the potentiating effect of magnesium on the action of oxytocin on uterine smooth muscle (14). Somlyo et al. (15) reasoned that the critical level of magnesium ion concentration would probably be at the active membrane sites.

**Symptomatology**

In this study it is not possible to attribute any symptoms to magnesium depletion alone or any subjective improvement to magnesium therapy. No accounts of symptomatic magnesium depletion in humans were noted in the immediate postpartum period. Greenwald and associates (16) described hypomagnesemic tetany due to excessive lactation in a young woman 3 months postpartum, illustrating the cumulative effect of mineral losses through both pregnancy and lactation. The precise site and mechanism of magnesium activity and the pathogenesis of symptoms are not yet understood.

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**References**

12. **Barnes, B. A., O. Cope and E. B. Gordon.**


