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Salt Intake, Home Blood Pressure, and Perinatal Outcome in Pregnant Women

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Background: The relationship between salt (sodium chloride) intake and pregnancy-induced hypertension (PIH) remains unclear. The aim of this study was therefore to investigate the current status of salt intake during pregnancy and identify effective predictors for PIH.

Methods and Results: Participants were 184 pregnant women who collected 24-h home urine as well as early morning urine samples. We investigated urinary salt excretion, home blood pressure (HBP) measurements for 7 consecutive days before the 20th and after the 30th gestational week, and the development of PIH. Urinary salt excretion according to early morning urine before the 20th gestational week was 8.6±1.7 g/day, and was significantly correlated with that measured from 24-h collected urine. Early morning urine estimated urinary salt excretion was slightly but significantly increased during pregnancy. HBP was 102±10/63±8 mmHg before the 20th gestational week and 104±12/64±10 mmHg after the 30th gestational week. On multiple regression analysis, serum uric acid and body mass index, but not urinary salt excretion, contributed to HBP both before the 20th and after the 30th gestational week. Fourteen participants (7.6%) developed PIH. On multivariate analysis, higher HBP and older age, but not urinary salt excretion, were significantly associated with PIH.

Conclusions: Higher HBP and older age, but not urinary salt excretion, are predictors of PIH. (*Circ J* 2016; **80:** 2165–2172)

Key Words: Blood pressure; Pre-eclampsia; Pregnancy; Salt intake; Uric acid

Hypertension is one of the most common medical disorders during pregnancy. Hypertensive disorders complicate approximately 10% of all pregnancies.[1] Hypertensive disorders of pregnancy are usually classified into 4 categories: (1) gestational hypertension, rise in blood pressure (BP) after the 20th gestational week; (2) pre-eclampsia, newly developed hypertension with proteinuria after the 20th gestational week; (3) chronic hypertension, rise in BP before or until 20 weeks of pregnancy; and (4) superimposed pre-eclampsia, severe range BP and/or new-onset or worsening proteinuria on chronic hypertension, or proteinuria before 20 weeks of pregnancy and a rise in BP after 20 weeks.[2,3] They can cause a number of maternal and fetal problems with different pregnancy outcomes, such as stroke, heart and renal failure for the mother, premature delivery and low birth weight for the infant.[4–7] Therefore, both prevention and management of hypertension are extremely important in pregnant women.

Editorial p2094

Excessive salt (sodium chloride) intake is a well-known factor for the development of hypertension. Salt intake has tended to decrease in Japan, but it still remains higher than the recommended level. In the early part of the 20th century, salt restriction was recommended during pregnancy, particularly in women with pre-eclampsia. This practice began to be questioned after the 20th century because some reports showed that a low-salt diet can cause deleterious outcomes in both the mother and the baby.[8,9] Accordingly, the majority of clinicians no longer advise women to reduce salt intake during pregnancy.[10] The

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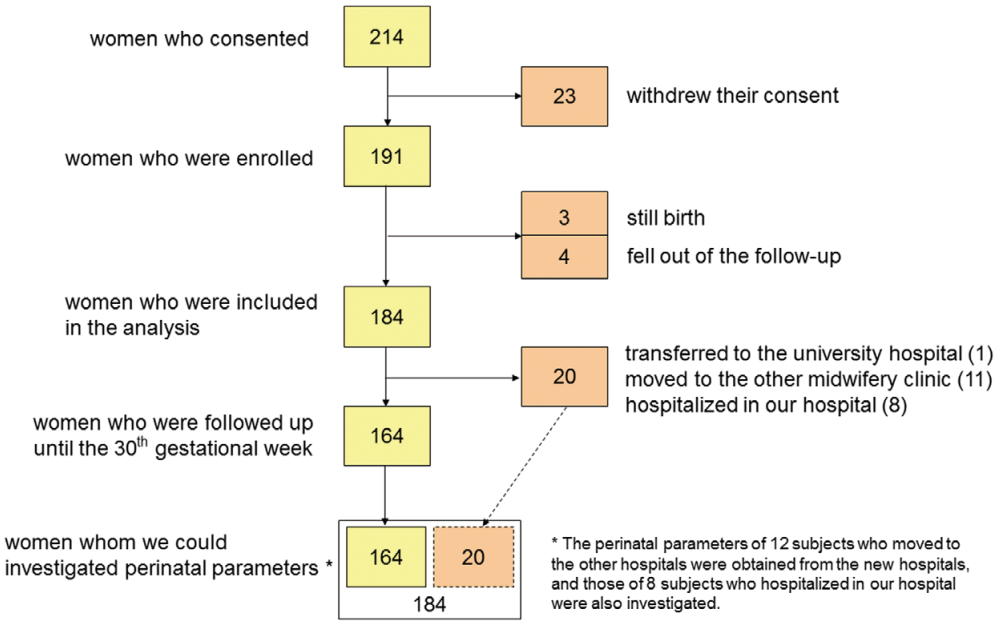

Figure 1. Subjects enrolled in the present study.

reports supporting the deleterious effect of salt restriction in pregnant women, however, are based on observations made in subjects on an extremely low-salt diet <3 g/day. Thus, it is unknown whether moderate salt restriction during pregnancy, or moderate salt restriction both before and during pregnancy, worsens maternal and fetal outcomes. Moreover, even the current status of salt intake in Japanese pregnant women has not been determined.

In the present study, therefore, the primary aim was to investigate the current status of salt intake in Japanese pregnant women by measuring urinary salt excretion. The second aim was to determine the factors predicting pregnancy-induced hypertension (PIH) and the birth of light-for-date (LFD) infants, as the maternal and the fetal outcomes. In order to evaluate BP accurately, home BP (HBP) was also measured in all participants.

Methods

Subjects

Participants were recruited from pregnant women who visited the Department of Obstetrics and Gynecology at the National Kyushu Medical Center, Fukuoka, Japan. All of the subjects were invited to participate in the study both by poster advertising and by their obstetricians in the first trimester. Among them, 388 pregnant women agreed to receive an explanation about this study from a physician (M.I.) between 1 October 2012 and 31 March 2014, and 214 of these women gave consent to participate. Women who were unable to undergo the first investigation (the first blood and urine sampling, and BP measurement) before the 20th gestational week, and those who had known heart disease or nephropathy were excluded. Patients with chronic hypertension or multiple pregnancy were included in the present study.

A total of 214 pregnant women at <20 weeks of gestation were enrolled in this study. This study was conducted in accordance with the institutional guidelines, and approved by the Ethics Committee of the National Kyushu Medical Center. Written informed consent was obtained from all participants.

One hundred and eighty-four participants were followed up until the end of pregnancy, but 20 of them lacked data for the period after the 30th gestational week because they were hospitalized or moved to another hospital before the 30th gestational week. Some participants moved to other hospitals in order to be closer to their parents. In all these cases, information on their deliveries was obtained from the new hospitals, as per participant consent obtained beforehand.

Baseline Subject Characteristics

Baseline age, body mass index (BMI) and biochemistry were recorded. Blood samples were taken for routine testing after overnight fast, including measurement of serum electrolytes (Na, K), blood urea nitrogen, serum creatinine, serum uric acid, total cholesterol, triglycerides and full blood cell count. We also investigated the past history of PIH, history of smoking habit, family history of hypertension and complications of chronic hypertension. Chronic hypertension was defined as hypertension before pregnancy or until the 20th week of gestation. Hypertension was defined as systolic BP (SBP) ≥140 mmHg and/or diastolic BP (DBP) ≥90 mmHg, or anti-hypertensive medication.

Urinary Salt Excretion

Urinary salt (sodium chloride) excretion was assessed on both 24-h home urine collection and early morning urine sampling. Urine samples were collected at 24-h intervals using a partition cup (proportional sampling method) that collects 1/50 of the urine over 24 h.[11] If the 24-h creatinine excretion was within ±30% of the estimated value, the urine collection was considered to be appropriately carried out. Before the 20th gestational week, and after the improvement of hyperemesis gravidarum, participants were asked to conduct both a 24-h home urine collection on the day before and an early morning urine sampling on the

Table 1. Demographic, Laboratory, Blood Pressure, and Perinatal Parameters of the Studied Subjects

	All subjects (n=184)	Non-PIH group (n=170)	PIH group (n=14)	P-value†
First trimester				
Age (years)	34.1±4.9	33.8±4.9	36.9±3.8	0.01
Pregnancy >40 years of age	12.0	10.6	28.6	0.07
BMI (kg/m²)	21.7±4.7	21.8±4.8	21.6±2.9	0.51
Parity (nulliparous)	55.4	54.7	64.3	0.49
Multiple pregnancy	7.6	7.7	7.1	0.95
Family history of hypertension	46.7	43.5	85.7	0.002
Chronic hypertension	8.2	4.7	50.0	<0.0001
BUN (mg/dl)	9.3±2.7	9.1±2.6	10.6±3.7	0.14
Serum creatinine (mg/dl)	0.5±0.1	0.5±0.1	0.5±0.2	0.13
eGFR (ml/min/1.73 m²)	126±23	126±22	132±33	0.54
Serum uric acid (mg/dl)	3.0±0.8	2.9±0.8	3.5±0.9	0.02
Hematocrit (%)	37.0±3.0	37.0±2.9	38.0±3.4	0.27
Urinary albumin/creatinine ratio (mg/gCr)	9.0±5.8	9.0±5.8	8.7±3.5	0.87
Third trimester	(n=164)	(n=150)	(n=14)	
BMI (kg/m²)	24.7±4.5	24.7±4.6	25.1±3.2	0.36
BUN (mg/dl)	8.1±2.9	7.9±2.1	10.6±6.6	0.06
Serum creatinine (mg/dl)	0.5±0.1	0.5±0.1	0.6±0.2	0.08
eGFR (ml/min/1.73 m²)	127±27	128±25	111±38	0.007
Serum uric acid (mg/dl)	3.7±1.0	3.6±0.9	5.0±1.3	<0.0001
Hematocrit (%)	32.7±2.7	32.8±2.7	32.3±3.0	0.62
Urinary albumin/creatinine ratio (mg/gCr)	23.4±97.5	11.1±6.8	389±421	<0.0001
BP before the 20th gestational week (mmHg)	(n=184)	(n=170)	(n=14)	
HBP	102±10/63±8	101±9/62±7	115±8/73±11	<0.0001
Clinic BP	115±12/66±9	114±12/65±8	129±11/78±11	<0.0001
BP after the 30th gestational week (mmHg)	(n=158)	(n=144)	(n=14)	
HBP	104±12/64±10	101±9/63±8	125±15/82±15	<0.0001
Clinic BP	115±12/67±9	113±10/66±7	132±16/83±15	<0.0001
Urinary salt excretion (g/day)	(n=184)	(n=170)	(n=14)	
Measured before the 20th gestational week	7.8±2.9 (n=126)	7.9±2.9 (n=116)	7.7±3.0 (n=10)	0.88
Estimated before the 20th gestational week	8.6±1.7	8.7±1.7	8.4±1.4	0.52
Averaged until the 30th gestational week	8.8±1.3	8.8±1.3	8.8±1.1	0.66
Perinatal outcome				
PIH	7.6	–	–	–
LFD infant	11.4	9.4	35.7	0.01

Data given as mean±SD or % . †PIH vs. non-PIH. BMI, body mass index; BP, blood pressure; BUN, blood urea nitrogen; eGFR, estimated glomerular filtration rate; HBP, home BP; LFD, light for date; PIH, pregnancy-induced hypertension; salt, sodium chloride.

day of the antenatal care visit. Estimation of 24-h urinary salt excretion using early morning urine sample was carried out as follows: $21.98\times(S_{UNa}/(S_{UCr}/10)\times PR_{Cr})^{0.392}$, where S_{UNa} is the spot urine Na (mEq/L), S_{UCr} is the spot urine Cr (mg/dl), and PR_{Cr} is the predicted value of the Cr. PR_{Cr} was determined as follows: PRCr=–2.04×age+14.89×weight(kg)+16.14×height (cm)–2,244.45.[12] In total, 184 participants were asked to conduct 24-h home urine collection and early morning urine sampling. Fifty-eight participants, however, were unable to provide all the samples due to either poor condition or urgent business, leaving 126 participants who appropriately provided all the requested samples. After the 20th week of gestation, urinary salt excretion was assessed using the early morning urine samples collected on each day of the check-up visits during pregnancy.

BP Measurement

Clinic BP (CBP) was measured using a BP-203RV (Omron Healthcare, Kyoto, Japan) based on the cuff-oscillometric method. After 1 or 2 min of rest in the sitting position, CBP was measured twice at each antenatal care visit during pregnancy.

HBP was measured twice at each occasion using an HEM-7051 (Omron Healthcare, Kyoto, Japan) based on the cuff-oscillometric method. The patients were asked to measure HBP at their upper arm within 1 h of waking up, after micturition, before breakfast, while seated, after resting >1 min. HBP was measured for 7 consecutive days including the day of home urine collection before 20 weeks of gestation. In addition, HBP was also measured for 7 consecutive days after 30 weeks of gestation.

Definition of PIH and Birth of LFD Infants

PIH was defined as gestational hypertension (rise in BP to ≥140/90 mmHg); pre-eclampsia (newly developed hypertension ≥140/90 mmHg with proteinuria ≥300 mg/day); or superimposed pre-eclampsia after the 20th gestational week on chronic hypertension (BP rise to ≥160/110 mmHg, and/or new-onset

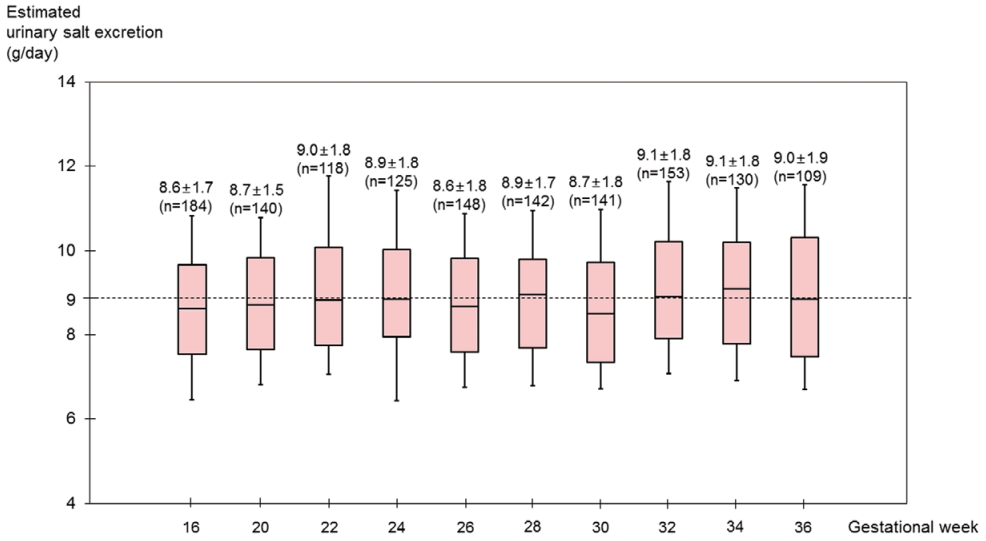

Figure 2. Serial change of urinary salt excretion estimated by early morning urine during pregnancy.

Table 2. Multiple Linear Regression Analysis for HBP

Parameter	β	P-value
Model 1		
First trimester serum uric acid	2.61	<0.01
First trimester BMI	0.84	<0.0001
Model 2		
Third trimester serum uric acid	4.02	<0.0001
Third trimester BMI	0.86	<0.0001

Model 1: dependent variable, home systolic BP before the 20th gestational week; independent variables, age, parity (nulliparous), multiple pregnancy, family history of hypertension, BMI, serum uric acid, eGFR, triglyceride, total cholesterol, hematocrit, platelet at the first trimester, estimated urinary salt excretion before the 20th gestational week. Model 2: dependent variable, home systolic BP at the third trimester; independent variables, age, parity (nulliparous), multiple pregnancy, family history of hypertension, BMI, serum uric acid, eGFR, hematocrit at the first trimester, urinary salt excretion averaged until the 30th gestational week. Abbreviations as in Table 1.

or worsening proteinuria ≥300 mg/day). We also investigated the birth of LFD infants as the fetal outcome. LFD was defined as body weight below the 10th percentile, based on Japanese percentile charts for birth weight.

Statistical Analysis

Statistical analysis was carried out with SAS for Windows, version 9.2 (SAS Institute, Cary, NC, USA). Data are expressed as mean±SD or a percentage unless otherwise stated. Comparisons between groups were done using either Student's t-test or Mann-Whitney U-test for continuous variables and Fisher exact test for proportions. Change in variables during pregnancy was evaluated using generalized linear models. Associations of the variables with BP were assessed with multiple linear regression models. Associations of the variables with perinatal outcome were analyzed using logistic regression models. $P<0.05$ was considered statistically significant.

Results

Clinical Subject Characteristics

Subject selection is shown in Figure 1. A total of 214 pregnant women gave consent to participate, but 23 withdrew consent. Therefore, 191 women were enrolled in the study. Three were excluded because of fetal death (spontaneous abortion) during pregnancy, 4 were lost to follow up.

Overall, 184 women were followed up until the end of pregnancy and included in the analysis. Data after the 30th gestational week were available for 164 of these participants. Among the 20 women lacking such data, 1 was transferred to another university hospital because she was carrying monochorionic monoamniotic twins. Eleven were moved to another obstetric hospital that was closer to their parents. Eight were hospitalized before the 30th gestational week due to possible premature delivery, or fetal problems related to fetal growth restriction. Four women were hospitalized before the 30th gestational week because of PIH. For these 4 women, biochemistry data were obtained on the day of hospitalization and BP from 7 consecutive measurements on the day after admission. These data were used as the data after the 30th gestational week.

The demographic, laboratory, perinatal, and BP parameters are listed in Table 1. Mean subject age was 34.1±4.9 years at enrollment, BMI was 21.7±4.7 kg/m^2, 55.4% of the subjects were nulliparous, and 8.2% of them had chronic hypertension (1.6% were taking antihypertensive medication). With regard to social history, only 1 participant had a smoking habit before pregnancy, and that patient had stopped when she became pregnant.

Urinary Salt Excretion in Pregnant Women

Urinary salt excretion estimated using early morning urine before the 20th gestational week was 8.6±1.7 g/day. In contrast, urinary salt excretion on 24-h collected urine of those who appropriately underwent urine sampling (n=126) before the 20th gestational week was 7.8±2.9 g/day. Early morning urine estimated urinary salt excretion significantly correlated with that measured using 24-h collected urine ($r=0.50$, $P<0.0001$).

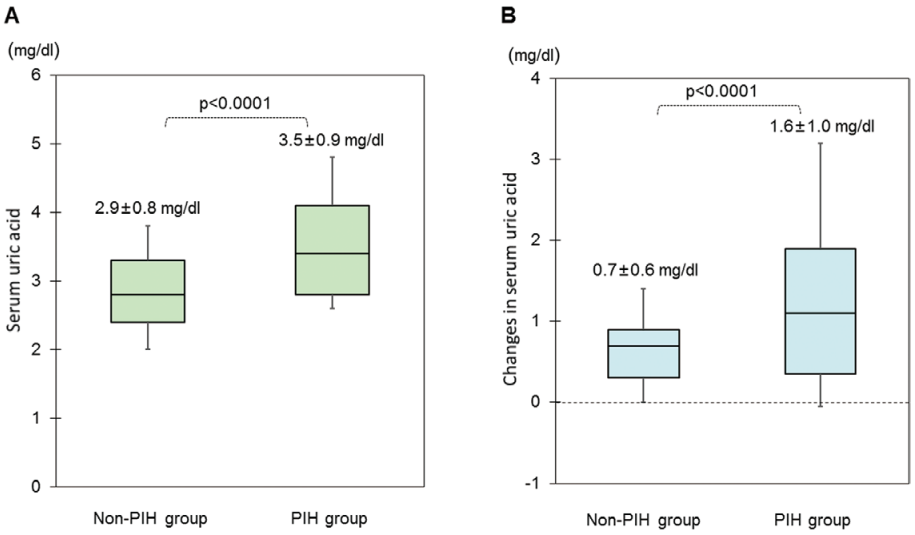

Figure 3. (**A**) Serum uric acid at the first trimester and (**B**) change in serum uric acid from the first to the third trimester in PIH and non-PIH groups.

Table 3. Logistic Analysis for PIH

Parameter	OR	95% CI	P-value
Age	1.17	1.02–1.35	0.03
Pregnancy >40 years	3.38	0.96–11.89	0.06
BMI	1	0.88–1.12	0.93
Parity (nulliparous)	1.49	0.48–4.63	0.49
Multiple pregnancy	0.93	0.11–7.67	0.95
Family history of hypertension	7.78	1.69–35.85	0.009
Chronic hypertension	20.25	5.71–71.79	<0.0001
BUN†	1.18	1.00–1.40	0.05
Serum creatinine†	0.15	<0.001–435.1	0.64
eGFR†	1.01	0.99–1.03	0.35
Serum uric acid†	2.15	1.18–3.92	0.01
Hematocrit†	1.13	0.94–1.35	0.20
HBP before the 20th gestational week			
SBP	1.16	1.08–1.24	<0.0001
DBP	1.14	1.07–1.22	<0.0001
Clinic BP before the 20th gestational week			
SBP	1.09	1.04–1.14	0.0003
DBP	1.16	1.09–1.24	<0.0001
Urinary salt excretion averaged until the 30th gestational week	0.98	0.66–1.45	0.90

†First trimester. DBP, diastolic blood pressure; SBP, systolic blood pressure. Other abbreviations as in Table 1.

The early morning urine estimated urinary salt excretion was slightly but significantly increased during pregnancy (P<0.05; Figure 2). Urinary salt excretion until the 30th gestational week was averaged for each participant, and mean, minimum and maximum were 8.8±1.3 g/day, 5.4 g/day and 13.0 g/day, respectively.

HBP Measurement

The HBP was 102±10/63±8 mmHg before the 20th gestational week and 104±12/64±10 mmHg after the 30th gestational week, which was significantly increased (P<0.05). Urinary albumin/creatinine ratio was 9.0±5.8 mg/gCr at the first trimester and 23.4±97.5 mg/gCr at the third trimester. Serum uric acid was significantly increased from 3.0±0.8 mg/dl at the first trimester to 3.7±1.0 mg/dl at the third trimester (P<0.0001). Estimated urinary salt excretion was not significantly correlated with either HBP before the 20th gestational week or HBP after the 30th gestational week. On multiple linear regression analysis, HBP was significantly associated with serum uric acid and BMI at both before the 20th gestational week and after the 30th (Table 2).

Table 4. Multivariate Logistic Regression Analysis for PIH

Parameter	OR	95% CI	P-value
Age	1.18	1.01–1.37	<0.05
HBP before the 20th gestational week			
SBP	1.15	1.08–1.22	<0.0001
DBP	1.14	1.07–1.22	<0.0001

Independent variables: age, family history of hypertension, first trimester serum uric acid, and HBP before the 20th gestational week. Abbreviations as in Tables 1,3.

Development of PIH and Birth of LFD Infants

Fourteen women (7.6%) developed PIH, and 8 developed PIH with proteinuria. Urinary albumin/creatinine ratio was significantly increased from 8.7±3.5 mg/gCr at the first trimester to 389±421 mg/gCr at the third trimester in those who developed PIH. Mean neonatal birth weight was 2,847 g, and 21 LFD infants (11.4%) were born. Table 1 lists the difference in demographic, laboratory, perinatal, and BP parameters between the non-PIH group and PIH group. Women who developed PIH were significantly older, were more likely to have a family history of hypertension, and had higher serum uric acid at the first trimester. In addition, they had higher HBP and CBP before the 20th gestational week. Moreover, the change in serum uric acid from the first to the third trimester was significantly higher in those who developed PIH compared with non-PIH patients (+1.6±1.0 mg/dl vs. +0.7±0.6 mg/dl, P<0.001; Figure 3). Table 3 lists the results of logistic regression analysis for the development of PIH. Neither urinary salt excretion averaged until the 30th gestational week nor change in urinary salt excretion was associated with the development of PIH. The unadjusted OR for age, family history of hypertension, serum uric acid at the first trimester, HBP, and CBP before the 20th gestational week were significantly higher in the PIH group than in the non-PIH group. On multivariate analysis, higher HBP before the 20th gestational week and older age were significantly associated with the development of PIH after adjustment for family history of hypertension and serum uric acid at the first trimester. The adjusted OR was 1.15 for home SBP (95% CI: 1.08–1.23, P<0.0001), 1.14 for home DBP (95% CI: 1.07–1.22, P<0.0001), and 1.18 for age (95% CI: 1.01–1.37, P<0.05; Table 4). Maternal urinary salt excretion was not associated with the likelihood of LFD infants.

Discussion

To the best of our knowledge, the present study is the first to determine the current status of actual salt intake estimated on urinary salt excretion concomitant with HBP measurement in pregnant women in Japan. Urinary salt excretion estimated using early morning urine was approximately 9 g/day throughout pregnancy, and it slightly but significantly increased during pregnancy. Based on the present results, daily salt intake in pregnant women in Japan might be approximately 10 g/day, because salt loss through perspiration or stool excretion is considered to be 1.0 g/day on average.[13] The salt intake in pregnant women in this study was similar to or slightly higher than that in Japanese non-pregnant women in their 20 s, 30 s and 40 s reported from the national health and nutrition survey (8.6 g/day for women in their 20 s, 8.9 g/day for those in their 30 s, and 8.7 g/day for those in their 40 s).[14] The Japan Society for the Study of Hypertension in Pregnancy recommends a salt intake <10 g/day for prevention of PIH.[15] In this study, 38% of the subjects had urinary salt excretion >9 g/day (equivalent to salt intake 10 g/day). This suggests that as many as one-third of all pregnant women could have excessive salt intake, therefore it is strongly suggested that individual salt intake be evaluated before providing nutrition guidance for pregnant women.

We also investigated the relationship between urinary salt excretion and perinatal outcome. Urinary salt excretion estimated on early morning urine was not significantly correlated with HBP during pregnancy. Moreover, urinary salt excretion up to the 30th gestational week was not associated with the development of PIH and the likelihood of giving birth to an LFD infant. These suggests that urinary salt excretion observed in this study (5–13 g/day) is unlikely to be related to deleterious outcomes for either mothers or infants.

Family history of pre-eclampsia, nulliparity, multiple pregnancy, obesity, higher BP, and older age are risk factors for pre-eclampsia.[16] In the present study, however, only higher HBP before the 20th gestational week and maternal older age were associated with the development of PIH. This suggests that these factors could be among the most important risk factors for PIH, and in a population in which maternal age is increasing such as in Japan, the association of hypertension with advancing age will inevitably contribute to higher BP in pregnant women.

In the present study, we focused on the role of serum uric acid in the development of PIH. Serum uric acid was significantly associated with HBP both before the 20th gestational week and after the 30th. Serum uric acid in the first trimester was significantly related to the development of PIH, although this association disappeared after adjustment for other confounding factors. Serum uric acid tends to decrease until approximately the 20th gestational week primarily in normal pregnancy because of hemodilution due to plasma expansion, despite the fact that the placenta and the growing fetus are important additional sources of purines.[17] Serum uric acid in the first trimester has been associated with the development of pre-eclampsia in the general population, but the causal relationship was not clear.[18,19] Serum uric acid in the third trimester has also been associated with the development or severity of pre-eclampsia.[20–23] In the present study, however, it may be inappropriate to analyze the relationship between third trimester serum uric acid and the development of PIH, because in the present study, third trimester serum uric acid included data from the day on which PIH developed. The advantage of the present study is that it investigated the effects of first trimester serum uric acid on the development of PIH. We showed that not only first trimester serum uric acid (3.5±0.9 mg/dl vs. 2.9±0.8 mg/dl, P<0.0001) but also the change from the first to the third trimester (+1.6±1.0 mg/dl vs. +0.7±0.6 mg/dl, P<0.0001) was significantly higher in women who developed PIH. This indicates that both basal serum uric acid and its increase during the advanced stage of pregnancy have pathogenic significance in the development of PIH.

None of the variables investigated in the present study were significantly related to the delivery of LFD infants. At the very least, low salt intake, to approximately 6 g/day, which is equivalent to urinary salt excretion 5 g/day, may not affect fetal outcome. In contrast, the prevalence of PIH in the present participants was higher (7.6% vs. 4.3%) than that among pregnant women in a previous nationwide survey conducted in Japan.[24] The present prevalence of PIH with proteinuria, however, was consistent with a global report in which PIH with proteinuria was estimated to complicate 2–8% of pregnancies.[1] In the present study, in the women who developed PIH, 7 (46.7%) with chronic hypertension developed superimposed

pre-eclampsia, and 7 (4.1%) of the women without chronic hypertension developed PIH. The incidence of superimposed pre-eclampsia in women with chronic hypertension is nearly eightfold higher than that of pre-eclampsia in the general pregnancy population,[25] similar to the present results.

Hypertensive disorders in pregnancy are starting to be encountered with greater frequency due to older maternal age, which is one of the major risk factors for hypertension. In addition, higher BP at the first visit is associated with an increased incidence of pre-eclampsia.[16] The present results support previous findings.[16] It is well known that excessive salt intake is associated with hypertension both in the general population and in hypertensive patients. In the present study, urinary salt excretion was not significantly associated with BP. In contrast, Robinson showed that addition of a substantial amount of salt considerably reduced both the incidence of pre-eclampsia and fetal mortality,[26] and a recent study has suggested that salt intake seems to aid in BP lowering in pregnancy for reasons that are unclear.[27] Despite these previous findings, the appropriate salt intake for the prevention and management of hypertension in pregnant women still remains unclear. Further studies are necessary to investigate the incidence of PIH and fetal outcome according to level of salt intake.

The present study had several limitations. First, follow-up measurements of urinary salt excretion were estimated using early morning urine samples. The measurement of urinary salt excretion on 24-h urine is considered to be the most reliable method to assess salt intake,[28] and thus we used a partition cup to collect 24-h urine before the 20th gestational week.[29] In contrast, estimation of urinary salt excretion using morning urine or casual urine are less reliable but more practical.[12,30] To confirm the validity of estimated urinary salt excretion, we compared early morning and 24-h urine collection urinary salt excretion before the 20th gestational week. Given the good correlation between these 2 values, early morning urine sample urinary salt excretion was used for the follow-up period. Second, the participants were recruited at a national medical center to which relatively high-risk pregnant women are referred by their general practitioners. The reasons for referral included advanced maternal age, obesity, complications of pelvic organic disease (including past history of cesarean section), internal complications (collagen disease, hyper/hypothyroidism, or diabetes), past history of PIH, or chronic hypertension. These factors may have led to participant-selection bias. The mean age (34.1±4.9 years) and mean CBP before the 20th gestational week (115±12/67±9 mmHg) were higher than those in pregnant women in a previous nationwide survey conducted in Japan (30.9±6.4 years and 113±13/66±9 mmHg, respectively).[24] Moreover, 8.2% of women had chronic hypertension, which is higher than that previously reported (3–5% of all pregnancies).[31,32] In addition, the participants live in the area close to National Kyushu Medical Center, Fukuoka, thus we may be unable to extrapolate the present observations to the general population in Japan. Third, the participants comprised 184 pregnant women including only 14 subjects who developed PIH, therefore the power to detect associations between salt intake, HBP, and PIH was limited by the small sample size. It is assumed that the influence of higher salt intake on BP and the development of PIH may vary among individuals. Further studies with sufficient sample size are necessary to confirm the findings. Finally, the present study lacked hemodynamic data. It has been shown that hemodynamic profile differs with the type of hypertension in pregnancy.[33] Hemodynamic assessment will need to be included in further studies with a larger sample size.

Conclusions

This study is the first to investigate the current status of salt intake in pregnant women in Japan. Urinary salt excretion in the present group of Japanese pregnant women was approximately 9 g/day on average. Urinary salt excretion was not associated with the development of PIH or the birth of LFD infants. The development of PIH was predicted by higher HBP before the 20th gestational week and older maternal age. Moreover, a possible role of elevation of serum uric acid is indicated in the development of PIH. The present study, however, did not provide evidence on whether mild–moderate salt restriction is safe and effective during pregnancy, therefore further studies are necessary to investigate this.

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