Sexual magnesium and calcium in preeclampsia: a comparative study at the Korle-Bu Teaching Hospital, Ghana

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Background: A large percentage (16% of maternal mortality in developed countries, compared to 9% in developing countries), is due to hypertensive disorders in pregnancy. The etiology of preeclampsia remains unknown, with poorly understood pathophysiology. Magnesium and calcium play an important role in vascular smooth muscle function and therefore a possible role in the development of preeclampsia.

Aim: We aimed to compare serum magnesium and total calcium levels of preeclamptic and normal pregnant women at the Korle-Bu Teaching Hospital in Ghana.

Patients and methods: A comparative cross-sectional study involving 30 normal pregnant and 30 preeclamptic women with >30 weeks gestation and aged 18–35 years, was conducted at the Korle-Bu Teaching Hospital. Magnesium and calcium were determined using a flame atomic absorption spectrometer.

Results: Mean serum magnesium and total calcium levels in preeclamptic women were 0.70±0.15 and 2.13±0.30 mmol/L, respectively. Mean serum magnesium and total calcium levels in normal pregnant women were 0.76±0.14 and 2.13±0.35 mmol/L, respectively. There was a statistically nonsignificant difference in serum magnesium and total calcium in preeclamptic women compared to normal pregnant women, with p-values of 0.092 and 0.972, respectively.

Conclusion: Serum magnesium and total calcium, therefore, seem not to differ in preeclamptic women compared to normal pregnant women in Ghana.

Keywords: electrolytes, maternal deaths, pregnant, hypertension, Ghanaian women

Introduction

Preeclampsia is one of the commonest etiologies of fetal and maternal mortality and morbidity.1 The incidence of preeclampsia in developing nations is estimated to be 4–18%.2 Thus, 16% of all maternal mortality in developed countries and 9% of maternal mortalities in Asia and Africa are said to be due to hypertensive disorders in pregnancy.3 Moreover, 18% of 724 total maternal deaths at the Korle-Bu Teaching Hospital between 1984 and 1994 were due to hypertensive disorders in pregnancy, including preeclampsia.4 A worldwide perinatal and neonatal mortality rate of 10% is associated with preeclamptic disorders, with prematurity as the commonest cause of the neonatal deaths.5 Current evidence suggests that the endothelial dysfunction seen in preeclamptic pregnant women may persist years after the episode, and therefore preeclamptic women may be at high risk of cardiovascular diseases later in life.6

Though the etiology of preeclampsia remains unclear, many theories suggest abnormal placental implantation and abnormal trophoblastic invasion as possible causes.7 The molecular basis of this condition is unresolved in literature.8 It has been postulated...
that fluctuations in maternal serum ions may be the precipit-
ating cause of elevated blood pressures in preeclampsia.10
Dietary deficiency of mineral ions has been shown to have a
harmful effect on the pregnant mother and growing fetus
and possibly complicate preeclampsia.11 Dietary deficiency
of magnesium has been established to play a role in blood
pressure regulation and hence development of preeclampsia.12
Evidence supporting routine magnesium supplementation for
all pregnant women has not been substantiated by research,
though most studies have reported reduced magnesium levels
in pregnancy and worse levels in preeclampsia.13–18 However,
other studies have also reported a nonsignificant change in the
serum magnesium levels of preeclamptic women compared
to normal pregnant women.19–21

Various studies have also reported reduced serum calci-
um levels in preeclampsia compared to normal pregnant
women.19,20–24 Calcium supplementation has been reported to
half the risk of development of preeclampsia.25 Kanagal et
al,26 in their study on calcium supplementation in pregnancy,
recognized that daily calcium supplementation of 1.5–2 g
reduced the blood pressure, prevented the development of
preeclampsia in normotensive pregnant women as well as
reduced morbidity and mortality, a finding supported by
Hofmeyr et al27 in their systematic review on calcium supple-
mentation in pregnant women at the community level. Other
studies, however, noted a nonsignificant difference in serum
levels of calcium in preeclampsia compared to normotensive
pregnant women.19,27–29 In a prospective study, Levine et al30
also observed that calcium supplementation during pregnancy
does not prevent the development of preeclampsia in healthy
nulliparous women.

The serum calcium and magnesium picture in preeclamp-
sia remains uncertain. We therefore sought to compare serum
total calcium and magnesium levels of preeclamptic
and normal pregnant women at the Korle-Bu Teaching Hospital
in Ghana.

Patients and methods
Study design
A comparative cross-sectional study was undertaken from
March to June 2016 at the Korle-Bu Teaching Hospital, Ghana.

Study site
The Korle-Bu Teaching Hospital is the largest tertiary referral
hospital in Ghana with 17 clinical and diagnostic departments
and a total bed capacity of 2,000, out of which 350 are in
the Department of Gynaecology and Obstetrics. The hospital
has a daily outpatient attendance of ~1,500 patients, out of
whom ~100 are antenatal patients. About 10,000 to 12,000
deliveries are conducted per year at the hospital.

Study population
All normal pregnant and preeclamptic women with gesta-
tions >30 weeks and aged between 18 and 35 years inclusive,
visiting the antenatal clinic at the Department of Obstetrics
and Gynaecology, constituted the target population, except
pregnant women with renal disorders, chronic hyperten-
sion, gestational or preexisting diabetes mellitus, and those
on magnesium and/or calcium therapy. Preeclampsia was
diagnosed using a systolic blood pressure ≥140 mmHg and
a diastolic blood pressure ≥90 mmHg plus a random urine
sample proteinuria ≥1+ on dipstick.31

Sample size and recruitment
The sample size was determined based on a formula by
Charan and Biswas32 considering a mean serum magnesium
level of 0.58 mmol/L in preeclamptic women compared to
0.73 mmol/L in normal pregnant women19 at a power of 80%
and a 5% significance level.

Sixty pregnant women comprising 30 normal pregnant
and 30 preeclamptic women with >30 weeks of gestation and
between the ages of 18 and 35 years inclusive, who met the
inclusion criteria were recruited consecutively and included
in the study after obtaining written informed consent.

Procedures
After obtaining an informed consent, participants’ demo-
graphic characteristics (age, weight and height) were
recorded on a structured data collection sheet. The blood
pressure of the participants was measured using a mercury
sphygmomanometer, twice in each participant 20 minutes
apart and averaged, noting the systolic and diastolic blood
pressures, from which the mean arterial pressure was calcu-
lated using the following formula:

\[
\text{Mean arterial pressure} = \text{Diastolic blood pressure} + \frac{1}{3} \text{(Pulse pressure)}
\]

where Pulse pressure = systolic blood pressure – diastolic
blood pressure

Using a 5 mL syringe on a 19G hypodermic needle, 4 mL
of venous blood was obtained from participants’ cubital vein
under aseptic conditions. For most serum ions, samples are to
be separated within 2 hours as recommended by the Clinical
and Laboratory Standards Institute.34 Blood samples drawn
were immediately placed in a plain test tube and sent to the
laboratory for analysis. At the laboratory, the blood samples

...
were centrifuged at 4,000 rpm for ~10 minutes to obtain the serum within 2 hours of sample collection, and subsequently stored at −20°C prior to analysis within 24 hours of sample collection. Serum magnesium and total serum calcium were determined using an atomic absorption spectrometer in an acetylene-air flame (Variant 240FS; Varian Australia Pty Ltd, VIC, Australia) with reference ranges of 0.74–1.03 mmol/L and 2.12–2.62 mmol/L, respectively.

Statistical analysis
Data obtained were stored in Microsoft® Access database 2010 and analyzed with SPSS® software version 20. The age, parity, body mass index (BMI), systolic blood pressure, diastolic blood pressure and mean arterial pressure of the participants are presented as mean values ± SDs. The mean serum magnesium and total calcium levels of normal pregnant women and preeclamptic women were compared using an independent t-test and are presented in a bar chart. Pearson correlation coefficient was used to determine the association between mean arterial pressure and serum calcium and magnesium levels. A p-value <0.05 was considered statistically significant.

Ethical issues
The Ethical and Protocol Review Committee of the University of Ghana School of Medicine and Dentistry, which is affiliated to the Korle-Bu Teaching Hospital approved the study (protocol identification number: CHS-Et/M.4-P4.5/2015-2016).

Results
Thirty normal pregnant and 30 preeclamptic women with >30 weeks of gestation and between the ages of 18 and 35 years were recruited into the study. Table 1 summarizes the characteristics of the pregnant women recruited. In this study, the mean arterial blood pressure (p<0.001), systolic blood pressure (p<0.001) and diastolic blood pressure (p<0.001) of preeclamptic women were significantly higher compared to normal pregnant women.

Mean serum magnesium levels of the study participants
There was no significant difference (p=0.092) in the mean serum magnesium levels between preeclamptic (0.70±0.15 mmol/L) and normal pregnant women (0.76±0.14 mmol/L), as shown in Figure 1.

A nonsignificant weak negative correlation was found between mean arterial pressure and serum magnesium levels in preeclamptic women (Pearson correlation coefficient r=-0.089; p=0.639), as shown in Figure 2.

Mean total serum calcium levels of the study participants
There was no statistically significant difference (p=0.972) in the mean total serum calcium levels between preeclamptic (2.13±0.30 mmol/L) and normal pregnant women (2.13±0.35 mmol/L), as shown in Figure 3.

A nonsignificant weak positive correlation was found between mean arterial pressure and serum total calcium levels in preeclamptic women (Pearson correlation coefficient r=0.047; p=0.806), as shown in Figure 4.

There was a nonsignificant negative correlation between serum total calcium and serum magnesium levels in preeclamptic women (Pearson correlation coefficient r=-0.328; p=0.077), as shown in Figure 5.

Discussion
Similar to the findings in other studies,35,36 our study showed no statistically significant relationship between maternal age and preeclampsia (p=0.358). However, this contrasts with the results of the study by Macdonald-Wallis et al,37 which was a very large longitudinal cohort study with a sample size of ~11,651 women living in a higher income region (Avon,

### Table 1 Summary of participants’ characteristics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Preeclamptic women</th>
<th>Normal pregnant women</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean±SD n=30</td>
<td>Mean±SD n=30</td>
<td></td>
</tr>
<tr>
<td>Age, years</td>
<td>30.97±5.51</td>
<td>29.93±2.60</td>
<td>0.358</td>
</tr>
<tr>
<td>Parity</td>
<td>1.70±1.42</td>
<td>1.13±1.41</td>
<td>0.567</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>32.03±7.52</td>
<td>30.50±5.50</td>
<td>0.374</td>
</tr>
<tr>
<td>SBP, mmHg</td>
<td>170.13±23.69</td>
<td>116.47±13.38</td>
<td>0.000*</td>
</tr>
<tr>
<td>DBP, mmHg</td>
<td>106.30±18.79</td>
<td>67.57±8.54</td>
<td>0.000*</td>
</tr>
<tr>
<td>MAP, mmHg</td>
<td>126.20±20.86</td>
<td>83.87±8.85</td>
<td>0.000*</td>
</tr>
</tbody>
</table>

Note: *Significant at p<0.05.
Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; MAP, mean arterial pressure; SBP, systolic blood pressure.
England), as compared to our sample population. Additionally, they considered the number of fetuses and the sex of the fetuses being carried by the women, as well as the educational status of the women, factors we did not consider in our study. Therefore, differences in the study design and the characteristics of the patient population studied may possibly account for the differences in the results.

We also noted a nonsignificant relation between pre-eclampsia and BMI ($p=0.374$), as noted by Onyegbule et al.,38 even though other studies have shown a strong association between BMI and pre-eclampsia.39–41 The findings of Poorolajal and Jenabi39 were derived from a meta-analysis, while ours is a case–control cross-sectional study, and this may therefore account for the differences in results. In contrast to our study, Hauger et al.41 conducted a large-sample-size multicenter study with possible confounding factors such as inclusion of women with known diabetes, known chronic hypertension and gestational diabetes. The BMI calculation in their study was also based on self-reported recall information of prepregnancy weight and therefore there is a possibility of information bias. There also could be differences in the diet of the studied population. These factors may account for the differences in their findings compared to ours.

The blood pressures (mean systolic, mean diastolic and mean arterial pressures) of the preeclamptic women were significantly elevated compared to the normal pregnant women ($p<0.001$), as expected per the case definition. Mean arterial pressure has been observed to be predictive of preeclampsia, even though other studies have reported otherwise.42

Magnesium and calcium are important cofactors for various enzymatic processes and water balance in cells.43 These trace elements play an essential role in vascular smooth muscle tone and contraction, and hence they are vital in blood pressure regulation.44

Various studies have reported a decrease in serum magnesium levels as a possible etiology of preeclampsia.13,14,16–18 This evidence is supported by the usefulness of magnesium sulfate therapy for prophylaxis and treatment of seizures associated with preeclampsia/eclampsia.45 However, this view is not universally accepted, as a Cochrane review involving 2,689 women from seven selected randomized and quasi-randomized trials found no high-quality evidence to support the beneficial effect of dietary magnesium supplementation in preventing the development of preeclampsia in pregnant women.46

Dietary deficiency of calcium, with consequent reduced serum calcium levels, has been implicated as a cause of preeclampsia in some studies.18,25,26,47,48 This has been explained

**Figure 1** Mean serum magnesium levels of preeclamptic and normal pregnant women.

**Figure 2** Correlation between serum magnesium levels and mean arterial pressure in preeclamptic women.
by the vasoconstrictive effect caused by reduced serum calcium levels.\textsuperscript{1,20–24} Stimulation of 1,25-dihydroxycholecalciferol has been implicated in this vasoconstrictive mechanism.\textsuperscript{18} This concept of a reduced serum calcium level in preeclampsia is not accepted universally.\textsuperscript{19,27,29,30,49} This is because other studies in preeclamptic women have noted relatively reduced 1,25-dihydroxycholecalciferol levels compared to normal pregnant women,\textsuperscript{50} with consequent increase in parathyroid hormone levels,\textsuperscript{1,20} causing reabsorption of calcium from the distal renal tubules and the intestines\textsuperscript{51–53} and therefore causing no significant change in the serum calcium levels. Parathyroid hormone also causes renin release with subsequent vasoconstriction and sodium retention in preeclamptic women.\textsuperscript{54}

Therefore, hypomagnesemia and hypocalcemia as etiopathologic factors in the development of preeclampsia are not a universal finding in literature.\textsuperscript{1,20,21,55} Various studies from different regions worldwide have reported varying results concerning the role of these trace elements in the etiology of preeclampsia.\textsuperscript{17,18,36,57} In this study, we observed no statistically significant difference in mean total serum calcium and magnesium levels of preeclamptic women compared to normal pregnant women ($p=0.092$), as found in a study by Magri et al.\textsuperscript{57} Similar studies conducted, including those done in sub-Saharan Africa using the same method of assay (atomic absorption spectrophotometry), in determining serum calcium and magnesium levels also show varying results.\textsuperscript{38,58,59} Ugwuja et al.\textsuperscript{58} in a study conducted among Nigerian women using atomic absorption spectrophotometry for assaying serum calcium and magnesium, found no significant difference in serum calcium but significantly reduced serum magnesium in preeclamptic women as compared to normal pregnant women. Another study conducted among Sudanese women using atomic absorption spectrophotometry for assaying serum calcium and magnesium found a decreased serum calcium level and an increased serum magnesium level\textsuperscript{59} in preeclamptic women as compared to normal pregnant women. These studies, including ours, were conducted in sub-Saharan Africa using the same method of assay for both ions, but the findings were different.

It is therefore possible that the differences in the findings may be attributed to not only differences in the method of assay of serum ions but also differences in dietary habits, genetic pools, as well as the social and economic lifestyle factors of the populations studied. The dietary history and socioeconomic status of the participants in this study were, however, not elucidated. Additionally, differences in sample size may also account for the observed differences in findings.

A nonsignificant negative correlation was observed between serum total calcium and serum magnesium levels in preeclamptic women (Pearson correlation coefficient $r=-0.328$; $p=0.077$) in contrast to the findings of Ephraim et al.\textsuperscript{60} who noted a nonsignificant positive correlation between serum calcium and serum magnesium levels. A nonsignificant weak negative correlation was observed between mean arterial pressure and serum magnesium levels in preeclamptic women (Pearson correlation coefficient $r=-0.089$; $p=0.639$). A nonsignificant weak positive correlation was observed between mean arterial pressure and serum total calcium levels in preeclamptic women (Pearson correlation coefficient $r=0.047$; $p=0.806$). Therefore, total serum calcium and serum magnesium may be weak predictors of mean arterial pressure in preeclamptic women.
Conclusion
There was no significant difference in the mean serum levels of magnesium and total calcium between preeclamptic and normal pregnant women.

Total serum magnesium and calcium therefore seem not to differ in preeclamptic women in comparison with normal pregnant Ghanaian women.

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Disclosure
The authors report no conflicts of interest in this work.

References

Figure 5 Correlation between serum magnesium levels and total serum calcium levels in preeclamptic women.


