The association of serum dephosphorylated-uncarboxylated matrix gamma carboxyglutamate protein (dp-ucMGP) as a marker of vascular vitamin K status with allograft function in kidney transplant recipients

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Introduction: Kidney transplantation has considerably increased the survival and life quality of patients with end-stage renal disease (1-3). However, long-term consequences like cardiovascular disease (CVD) and vascular calcification are still the leading cause of mortality after transplantation (4-8). Among different risk factors of CVD, there is some evidence for significant association between vitamin K deficiency and vascular calcification in patients with chronic kidney disease (9-11). It is also reported that...
vitamin K level may be low in kidney transplant recipients (12-14).

Vitamin K has a fundamental role in blood coagulation and carboxylation of gamma glutamate proteins including matrix gamma carboxylglutamate protein (MGP). MGP is expressed extensively in kidney and serum level of its inactive form, dephosphorylated - uncarboxylated MGP (dp-ucMGP), is an indicator of vitamin K and also vascular calcification (15-18).

It seems that micro-vascular dysregulation of kidney such as micro-albuminuria is inversely related to the circulating level of vitamin K and activated MGP levels (19). There is some evidence that serum level of dp-ucMGP is directly related to proteinuria and serum creatinine and inversely related to renal function (GFR, glomerular filtration rate) in patients with CKD (20-26).

Objectives
The present study aimed to investigate the serum level of dp-ucMGP as a potential marker of vascular calcification and vitamin K status in kidney transplant recipients along with its relationship to the allograft function.

Patients and Methods
Study design and population
The present cross-sectional investigation was conducted on kidney transplant recipients of Transplant Center-Imam Reza hospital (Tabriz, Iran). The inclusion criteria were as follow; age 18 to 70 years old and appropriate kidney function (serum creatinine <1.6 mg/dL). The exclusion criteria were: acute kidney rejection during the first month after transplantation, any history of major cardiovascular complications including myocardial infarction, congestive heart failure and stroke, active HIV, CMV and HBV infection, a history of thrombosis or coagulation disorders and contemporary treatment with anticoagulants. During our study, total number of 90 patients were enrolled within their 6-12 months of kidney transplantation.

Anthropometric and biochemical assessments
General information including age, gender, transplantation type, education and smoking were asked from the participants, height and weight were measured and the body mass index (BMI) was calculated [weight (kg)/height (m)^2]. Blood pressure was measured in the right arm, in the seated position after five minutes’ rest using an automated sphygmomanometer.

Venous blood samples were drawn after an overnight fast. Fasting blood sugar, serum urea, creatinine, cholesterol and triglyceride were analyzed by standard clinical laboratory methods. Serum levels of dp-ucMGP were measured using the human ELISA kit (Shanghai Crystal Day Biotech Co., Ltd., Shanghai, China) based on the principle of double-antibody sandwich technique. GFR was estimated based on the CKD-EPI (chronic kidney disease epidemiology collaboration) equation (2009) and the MDRD (modification of diet in renal disease study) equation using the online eGFR calculator of national kidney foundation (https://www.kidney.org/professionals/KDOQI/gfr_calculator).

Ethical issues
Human rights were respected in accordance with the Helsinki Declaration 1975, as revised in 1983. The ethical committee of Tabriz University of Medical Sciences approved this study (Ethical code; IR.TBZMED.REC.1396.443). The informed consents were taken from the patients. This study was extracted from the M.D thesis of Pooya Fathalizadeh, (#58350) at Tabriz University of Medical Sciences.

Statistical analysis
Data were analyzed using SPSS software, version 16.0 (IBM Corp., Armonk, NY, USA). The normal distribution of variables was tested by the Kolmogorov–Smirnov test. Results were reported as mean (SD) or median (25th, 75th percentiles). Regarding the nonparametric feature of serum MGP level, Spearman’s rho correlation test was used to assess its relation with kidney function and other parameters. The significance level was set at P ≤ 0.05.

Results
Demographic characteristics of patients are presented in Table 1. The mean age of participants was 44.1±13.05 years old. In the studied cases, 41.1% were women and 58.9% were men. The anthropometric and biochemical

| Table 1. The demographic information of participants (n=90) |
|-------------|-----------|
| No. (%)     | 44.1±13.05 |
| Sex         | 37 (44.1%) |
|            | 53 (58.9%) |
| Transplant type | 76 (84.4%) |
| Brain-death donor | 14 (15.6%) |
| Smoking     | 80 (88.9%) |
|            | 10 (11.1%) |
| Literacy    | 19 (21.1%) |
| Under diploma | 37 (41.1%) |
| Diploma     | 22 (24.4%) |
| Undergraduate degree | 3 (3.3%) |
| Bachelor and higher | 9 (10%) |

*Mean ± SD
characteristics of patients are summarized in Table 2. Mean body weight changes within 6-12 months (average 7.46±1.65 months) after transplantation was about 4.06±7.45 kg, and their mean BMI was 25.77±4.42 kg/m², indicating the overweight trend after kidney transplantation.

The mean serum levels of urea and creatinine were 38.78±12.19 mg/dL and 1.26±0.25 mg/dL, respectively. The estimated GFR (eGFR) was 63.62±15.02 mL/min/1.73 m² based on the CKD-EPI formula and was 57.45±12.61 mL/min/1.73 m² based on the MDRD formula. The median (IQR) of serum level of dp-ucMGP was reported as 2.40 (1.60-3.20) µg/L. Most of the participants (eighty percent) had a normal range of serum dp-ucMGP (<4 µg/L). However, 10% of them had high serum dp-ucMGP (>12 µg/L).

The association of serum dp-ucMGP with kidney function is presented in Table 3. Serum dp-ucMGP did not have any statistically significant relationship with serum urea, serum creatinine, eGFR–EPI and eGFR–MDRD (P>0.05). Moreover, no significant association of serum dp-ucMGP with any other baseline parameters including weight and blood pressure was detected (P>0.05; Table 4).

Discussion

Vascular calcification is an important predictor of CVD and a possible pathologic factor in transplant rejection (27-29). There are different risk factors for development of coronary artery calcification (CAC) after transplantation including immunosuppressive therapy (30), post-transplant diabetes, lower 25(OH) D3 level, high serum triglyceride, high diastolic blood pressure, Caucasian race and high BMI (31-32). The circulating level of dp-ucMGP considers as a relatively new marker of vascular vitamin K status and also vascular calcification. Decreased vitamin K consumption and increased serum dp-ucMGP level are common in kidney transplant recipients which can affect kidney allograft function and cardiovascular consequences (33).

Some evidence revealed a significant reverse relation between dp-ucMGP and kidney function (9,13,21,34). Results of a cohort study showed that kidney transplant recipients at the highest quartile of dp-ucMGP had a higher risk of developing transplant failure and mortality risk (13). Recently, Puzantian et al significantly reported that dp-ucMGP level was progressively increased in CKD patients with decreasing renal function (35). However, according to our results, the association of serum dp-ucMGP with kidney function was not statistically significant.

Vitamin K exists in two forms of phylloquinone (K1) and menaquinone (K2), respectively, in plant and animal foods. As the intake of vegetables, meat and dairy products are encouraged to be decreased in CKD patients, it seems that vitamin K intake is low in these patients (9,19). Even after transplantation some of these restrictions are still continued and extend the domain of vitamin K deficiency to post-transplant era (12,33).

Results of Boxma et al in a group of kidney transplant recipients with stable alograft function, showed that they had low vitamin K intake, their plasma dp-ucMGP levels were high and they had an increased risk of arterial

Table 2. The anthropometric and serum biochemical characteristics of participants (n=90)

| Parameter                | Mean ± SD   |
|--------------------------|-------------|
| Weight (kg)              | 69.61±11.59 |
| Weight diff^             | 4.06±7.45   |
| BMI                      | 25.77±4.42  |
| SBP (mm Hg)              | 122.93±11.39|
| DBP (mm Hg)              | 76.41±9.36  |
| Total cholesterol        | 187.48±43.6 |
| Triglyceride             | 189.39±114.79|
| Urea (mg/dL)             | 38.78±12.19 |
| Creatinine (mg/dL)       | 1.26±0.25   |
| eGFR–EPI (mL/min/1.73 m²)| 63.62±15.02 |
| eGFR–MDRD (mL/min/1.73 m²)| 57.45±12.61 |
| dp-uc MGP (µg/L)**       | 2.40 (1.60-3.20) |

^ Weight differences after transplantation.  
** Data are presented as median (25th, 75th percentiles).

Table 3. The association of serum dp-ucMGP with kidney function

| Parameter | r    | P value* |
|-----------|------|----------|
| Serum urea| 0.132| 0.248    |
| Serum creatinine | 0.075| 0.511    |
| eGFR–EPI  | -0.088| 0.395    |
| eGFR–MDRD | -0.097| 0.439    |

**P values are based on the Spearman’s rho correlation test.

Table 4. The association of serum dp-ucMGP with some baseline parameters

| Parameter | r    | P value* |
|-----------|------|----------|
| Sex       | 0.094| 0.411    |
| Age       | 0.125| 0.271    |
| Weight    | 0.114| 0.319    |
| Weight diff^ | -0.013| 0.909    |
| BMI       | 0.047| 0.686    |
| FBS       | 0.083| 0.557    |
| Total cholesterol | -0.100| 0.453    |
| Triglyceride | -0.188| 0.159    |
| SBP       | 0.101| 0.377    |
| DBP       | 0.107| 0.353    |

**P values are based on the Spearman’s rho correlation test.
calcification (33). During a randomized clinical trial, Holden et al showed that vitamin K supplementation in hemodialysis patients could decrease the development of CAC and mortality among this group (36). Vitamin K1 supplementation by reduction of inactive MGP level imposes this positive effect (37).

The definition for high dp-ucMGP is different because the results come from various studies population (38). As an additional word, because MGP activity depends on genetic background, the importance of its measurement and normal value definition in different population became more obvious.

Conclusion
To our knowledge, this is the first study that measures the circulating level of dp-ucMGP and its relation with allograft function in kidney transplant recipients. According to our results, the mean serum level of dp-ucMGP was in normal range. However, a small percentage of participants had high serum dp-ucMGP (more than 12 μg/L). Serum dp-ucMGP did not have any statistical significant association with serum urea, creatinine and kidney function. High serum level of dp-ucMGP may make kidney transplant recipients susceptible to cardiovascular events and transplant rejection. Therefore, further epidemiologic studies are needed to assess time trends of dp-ucMGP after renal transplant and its relation with kidney function.

Limitations of the study
Unfortunately, during the present study, we cannot assess the pulse wave velocity as a measure of arterial stiffness and vascular calcifications (Kauppiila score). Moreover, the other limitations of this study were the low sample size and lack of the evaluation of serum total MGP levels.

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Authors’ contribution
VEA contributed to design of the study, gathering the patients, data entering and data analysis and also preparing the manuscript. MRA, MMS, and SZV cooperated in design of the study, selecting the patients and final edition. ZSH prepared the primary draft of article. PF and SP contributed to gathering the patients. All authors read and signed the paper manuscript.

Conflicts of interest
The authors declared that there was no conflict of interest.

Ethical considerations
Ethical issues including plagiarism, double publication, and redundancy have been completely observed by the authors.

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