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Original article

Effect of nutritional education on serum potassium level in patients receiving haemodialysis

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Abstract. *Background:* The most effective and practical way to prevent hyperpotassemia, which is an important problem in patients receiving haemodialysis, is to limit potassium intake with diet. One of the most effective methods to be applied for this purpose is nutrition education. *Objective:* This study was aimed at investigating the effect of nutrition education given to patients receiving haemodialysis with hyperpotassemia on serum potassium levels. *Methods:* The study was conducted as a prospective intervention study. A total of sixty-eight participants over the age of 18, who received at least three haemodialysis sessions per week for more than six months, and whose serum potassium level was above 5.5 mEq/L were recruited in the study. *Intervention:* The participants in the intervention group (n=34) were given nutrition education and a handbook including information about potassium in haemodialysis treatment. No nutrition education was given to the participants in the control group (n=34). *Results:* The comparison of the pre- and post-nutrition education serum potassium levels and the mean potassium knowledge score of the participants in the intervention group demonstrated that while their serum potassium levels decreased significantly, their potassium knowledge score increased ($p < 0.05$). In the control group, no difference was determined between the participants' pre- and-post study serum potassium levels and potassium knowledge scores ($p > 0.05$). *Conclusions:* It was observed that the nutrition education given to patients receiving haemodialysis was effective in lowering the serum potassium levels of the participants.

Key words: Haemodialysis, hyperpotassemia, nutrition education.

Introduction

Potassium (K^+) is the most common cation in the body that plays a role in vital functions such as intercellular communication, muscle contraction, displacement of fluids between the body parts, transmission of impulses, and release of hormones. Potassium, which is taken into the human body by diet or by various ways (drugs, food additives, nutritional supplements, etc.), is removed by the kidneys or intestines (1). In individuals with normal renal functions, a very large amount of potassium excretion (90%) is carried out by the kidneys alone. The haemodialysis (HD) procedure, which artificially undertakes the functions of the kidney, realizes a significant part (80%) of the potassium excretion in the body. The amount of potassium excretion in haemodialysis treatment is 10% lower than the physiological process. The most practical and safe way to compensate for this decrease is to reduce the amount of potassium taken with diet (2).

Disruption of potassium homeostasis leads to some side effects in the body. Serum potassium levels are kept at a certain range through a strict control performed by various mechanisms. The reliable range for serum potassium level in adults is between 3.5 and 5.5 mEq/L. Hyperpotassemia is the condition in which serum potassium level exceeds 5.5 mEq/L. Patients receiving haemodialysis occur such symptoms as palpitations, nausea and muscle pain when the serum potassium level exceeds 6 mEq/L. When serum potassium level is above 6.5 mEq/L, it can cause serious complications such as ventricular arrhythmia, and some electrocardiographic changes (3). Life-threatening hyperpotassemia affects mortality rates in patients receiving haemeodialysis by 3-5% and therefore requires urgent action (4). Keeping the potassium content of the diet low reduces the risk of hyperpotassemia in patients receiving haemodialysis. The medical nutrition therapy of these patients should be arranged in a way to limit intake of foods with high potassium content, and the patients' serum potassium level should be decreased by ensuring their adherence with a balanced diet in terms of potassium content (5).

Patients receiving haemodialysis have some restrictions in their diets in terms of the mineral content of foods and the amount of fluid to be consumed. The most effective way to increase adherence with these restrictions in patients receiving haemodialysis is nutrition education (6). Nutrition educations specific to the situation or nutrients improve individuals' knowledge of the subject and positively affect their adherence with the diet (7). One of the nutrition educations that should be given to patients receiving hemodialysis should be about the amount of potassium intake with diet. This nutritional education, given by a multidisciplinary team including dietitians, is an important step that reduces the risk of hyperpotassemia (8). During this nutrition education about potassium, patients should be informed about the importance of nutrition in haemodialysis treatment, the potassium content of foods, effects of some cooking methods on the reduction of the potassium content of foods, and on serum potassium levels (9).

The aim of this study is to determine how one-on-one and face-to-face nutrition education about potassium affects serum potassium levels in patients receiving haemodialysis. In order to increase the effectiveness of nutrition education, a handbook about potassium was used and the nutrition education was applied repeatedly.

Material and Methods

This prospective intervention study conducted in a private haemodialysis center (Almet Dialysis Center, Kayseri, Turkey) included 68 patients receiving haemodialysis. Inclusion and exclusion criteria of the patients in the study were as follows:
Inclusion criterias were;

- Individuals who were older than 18 years of age,
- Individuals had been undergoing HD at least three times a week for more than six months
- Individuals had a serum potassium level ≥5.5 mEq/L,

Exclusion criterias were;

- Individuals who had received education on potassium previously
- Individuals who took potassium-lowering drugs
- Individuals whose serum potassium level was below 5.5 mEq/L during the month before the study.

All the participants were able to communicate, and to read and write enough to answer research questions. Ethics committee approval from Erciyes University Faculty of Medicine Ethics Committee (decision number: 2016/545) and the permission of the dialysis center where the study was to be conducted were obtained. After all the participants were informed about the purpose of the study, written consent was obtained from them.

Sample size calculation was based on the study conducted by Dağdeviren and Savaşer (10). The change in the knowledge level in the study sample was planned to be 5%, power analysis was performed at a power of 80% (= 0.20) and a confidence level of 95%

(α= 0.05), and it was considered appropriate to include 68 patients in the sample. Of them, 34 were assigned to the intervention group and 34 to the control group. Considering the possibility of losses during the study, it was decided to include 40 patients in the intervention group and 40 patients in the control group. The follow-up chart of the study is given in Figure 1.

In the study, a 36-item questionnaire was administered to the participants. Of the items, 11 questioned their sociodemographic characteristics whereas 25 were used to measure their potassium knowledge levels. While preparing the items used to measure the potassium knowledge levels, we utilized the sources in the literature, and consulted an expert dietician and a certified hemodialysis physician. The studies conducted by Dağdeviren & Savaşer (2003) and Durose *et al.* (2004) were used in the preparation of the format of the knowledge level questions in the questionnaire (7, 10). When the responses given to the items used to determine the potassium knowledge level were scored, each "correct" answer was given 1 point, and each "wrong" or "I do not know" answer was given 0 points. The highest possible score to be obtained from the questionnaire is 25. While the knowledge level of those whose score ranged between 0 and 12 points was considered "insufficient", that of those whose score ranged between 13 and 25 points was accepted as "sufficient". Based on the study conducted by Durose *et al.* (2004), the cut-off point of the total knowledge level score obtained from the questionnaires was determined (7).

The researcher did not make a weight measurement, because the body weight of each patient was measured before the HD session. The patients' weights were measured with a ±100 gr precision scale (Densi SI-300 M, Turkey) which could measure weights between 10 and 300 kg, and could be calibrated when necessary. The patients' height was measured by the researcher using a 1 mm precision portable height meter (SECA-213, Germany) which could measure heights between 20 and 205 cm, and could be calibrated. While the measurements were made, the patients stood in an upright position and faced straight ahead so that the upper part of their ears and the outer corner of their eyes were in a line parallel to the plane (Frankfort plane). In the HD center, the biochemical parameters of the patients are regularly checked on a monthly basis. The researcher obtained the serum potassium values of the patients from their medical records.

In order to prevent information exchange between the participants in the intervention and control groups, those who underwent HD treatment on Monday, Wednesday and Friday were assigned to the intervention group, and those who underwent HD treatment on Tuesday, Thursday and Saturday were assigned to the control group.

Implementation of the Study

The researcher administered the questionnaire used to measure the potassium knowledge levels of the participants before and after the study. The serum potassium values of the patients in both groups were recorded four times: before and after the first and second educations. In the HD center where the study was conducted, blood samples are routinely taken before the HD session, in the middle of the first week of each month. In this way, serum potassium levels of the patients were obtained from the patient files. This method was used in order to prevent possible deviations in potassium values.

The implementation of the nutrition education given to patients receiving haemodialysis was carried out between February and May 2017. Nutrition education given to the intervention group started right after the first blood draw. One month later, the first part of the training was completed and blood samples were taken again for analysis. This process was repeated in the second training program.

Intervention Group

The patients in the intervention group were given the individual nutrition education using the face-to-face communication technique by the researcher. The patients in this group participated in two nutrition education programs, the second of which was the repetition of the first one. Education programs consisted of two sessions. Each session took thirty minutes. After each session, a fifteen-minute question-answer activity was held. There was a one-week interval between two sessions. The second training program was started one month after the first education program was

completed. Both education programs had the same content and layout.

During the nutrition education, the patients were informed about the nutrition principles to be followed in the HD treatment, the definition of potassium and its functions in the body, the way potassium excreted from the body, the undesirable conditions caused by hyperpotassemia, the effect of the cooking style on the potassium level, and the foods that are low or high in potassium. After the education, the patients were given a handbook prepared by the researchers, about the topics discussed in the nutrition education.

Foods are generally classified as low, medium, high and very high in potassium (11). Tables showing the amount of potassium in foods in nutrition education are among the useful materials used in educations. Using the "traffic light" concept in the food content table is very useful to easily categorize the mineral content of foods and attract patients' attention (12). In our study, foods low, medium, high and very high in potassium were colored green, blue, light red and dark red respectively. The aim was to attract the patients' attention. In addition, the patients and their family members preparing their meals at home were also recommended to read the handbook.

Control Group

The patients in the control group were not given nutrition education. They were given another handbook in which only the general nutrition principles of dialysis treatment were described.

Analysis of the Study Data

The demographic characteristics of the patients participating in the study and their answers to the items in the questionnaire were analyzed through the frequency analysis, and the descriptive statistics values were calculated. Whether the data was normally distributed was checked using the Shapiro-Wilk test. In the comparison of independent groups (intervention-control), the Student's t-test was used for the data with normal distribution, and Mann-Whitney U test was used for the data without normal distribution. In the comparison of dependent groups (before and after), the paired t-test was used for the data with normal distribution, and Wilcoxon test was used for the data without normal distribution. While Spearman's rank correlation coefficient was used to determine the relationship between numerical variables, Pearson's chi-square test was used to determine the relationship between categorical variables. The statistical significance level taken into account in all the calculations and comments was $\alpha = 5\%$. All calculations were made using the IBM SPSS Statistics 24.

Results

The mean age of the patients was 57.59 ± 14.56 years. Of them, 54.4% (n = 37) were women. The demographic characteristics of the patients are given in Table 1. There was no significant difference between the patients in the intervention and control groups in terms of variables related to age, sex, educational status, duration of HD treatment, previous dieting status, and anthropometric measurements such as body mass index (BMI), body weight, and body height (Table 1).

Before the nutrition education was given, there was no significant difference between the control group and the intervention group in terms of their potassium knowledge levels ($p = 0.801$). However, after the nutrition training, the potassium knowledge levels of the participants in the intervention group were higher than were those of the participants in the control group ($p = 0.001$) (Table 2). This was because while the potassium knowledge scores of the patients in the intervention group increased significantly after the nutrition training ($p < 0.001$), there were no difference between the pre- and post-training potassium knowledge scores of the participants in the control group ($p = 0.064$) (Table 2).

Serum potassium levels of the patients in both the intervention and control groups were measured before and after the first and second education. There was no significant difference between the groups in terms of their serum potassium levels before the first education ($p = 0.968$). However, after the first nutrition education, serum potassium levels decreased significantly in the intervention group compared to the control group ($p = 0.002$). Before the second nutrition education, the difference between the groups in terms of their serum

Table 1. Sociodemographic, anthropometric and HD treatment characteristics of the patients

Variables	Intervention (n=34) mean ± SD	Control (n=34) mean ± SD	Total (n=68) mean ± SD	p
Sex				
Men	12 (35.3%)	19 (55.9%)	31 (45.6%)	0.088
Women	22 (64.7%)	15 (44.1%)	37 (54.4%)	
Educational Status				
Literate but not graduate any school	12 (35.3%)	4 (11.8%)	16 (23.5%)	
Elementary school graduate	11 (32.4%)	19 (55.9%)	30 (44.1%)	0.125
Junior high school graduate	2 (5.9%)	4 (11.8%)	6 (8.8%)	
Senior high school graduate	7 (20.6%)	6 (17.6%)	13 (19.1%)	
College graduate	2 (5.8%)	1 (2.9%)	3 (4.5%)	
Anthropometric Measurement				
Body Mass Index (BMI)	26.23 ± 5.39	26.92 ± 5.81	26.58 ± 5.57	0.615
Weight (kg)	68.68 ± 15.9	69.35 ± 13.58	69.01 ± 14.68	0.851
Height (cm)	162 ± 14	161 ± 11	161.4 ± 12.5	0.781
Duration of HD the treatment				
<2 years	4 (11.8%)	4 (11.8%)	8 (11.8%)	
2-4 years	7 (20.6%)	7 (20.6%)	14 (20.6%)	1.000
>4 years	23 (67.6%)	23 (67.6%)	46 (67.6%)	
Previous Diet				
Yes	8 (23.5%)	11 (32.4%)	19 (27.9%)	0.417
No	26 (76.5%)	23 (67.6%)	49 (72.15%)	

Values are shown as mean ± standard deviation. Chi-square (x^2) test was used. $p<0.05$*

Table 2. Differences between the patients' pre- and post-education potassium knowledge scores

Serum Potassium Levels (mEq/l)	Before the first education mean ± SD	After the first education mean ± SD	Before the second education mean ± SD	After the second education mean ± SD
Intervention (n=34)	5.81 ± 0.31	5.15 ± 0.64	5.47 ± 0.51	4.95 ± 0.47
Control (n=34)	5.81 ± 0.28	5.60 ± 0.52	5.33 ± 0.55	5.66 ± 0.61
Paired t test	t = -0.041, p = 0.968	t = -3.187, **p = 0.002***	t = 1.089, p = 0.280	t = -5.351, **p < 0.001***

Values are shown as mean ± standard deviation. The Paired t test was used. $p < 0.05$*

potassium levels was not significant (p = 0.280). After the second nutrition training, a sharp decrease was observed in the serum potassium levels of the participants in the intervention group compared to those in the control group (p <0.001) (Table 3).

The intergroup comparison of the changes in the serum potassium levels revealed that the nutrition education was effective. The change in the serum potassium levels of the patients in the control group before and after the education was not statistically significant (p = 0.099). However, post-education serum potassium levels of the patients in the intervention group were significantly lower than were their pre-education levels (p <0.001) (Table 4).

Table 3. Intergroup comparison of serum potassium levels in the first and second education periods

Serum Potassium Levels (mEq/l)	Pre-education mean ± SD	Post-education mean ± SD	Paired t test
Intervention (n=34)	5.81 ± 0.31	4.95 ± 0.47	t = 7.909, p <**0.001***
Control (n=34)	5.81 ± 0.28	5.66 ± 0.61	t = 1.696, p = 0.099

Values are shown as mean ± standard deviation. The Paired t test was used. $p < 0.05$*

Table 4. Intra-group differences between the pre- and post-education serum potassium levels of patients

Potassium Knowledge Score	Pre-Education mean ± SD	Post-Education mean ± SD	Paired t test or Wilcoxon Signed Rank test
Intervention (n=34)	8.35 ± 6.46	18.32 ± 2.83	Z = -5.093, p **< 0.001***
Control (n=34)	8.62 ± 5.58	9.59 ± 4.13	t = -1.914, p = 0.064
Wilcoxon Signed Rank test	Z = -0.252, p = 0.801	Z = -6.456, p **= 0.001***	

Values are shown as mean ± standard deviation. The Paired t test or Wilcoxon Signed Rank test was used. $p<0.05$*

Discussion

Haemodialysis is a renal replacement therapy (RRT) method whose main function is to remove residual substances accumulated in the blood. With this treatment method, the quality of life of the patients increases and their life span is prolonged (13).

Many patients receiving haemodialysis stated that adherence with dietary restrictions is the most challenging factor in HD treatment, as it affects their food choices and changes their lifestyle (14). Therefore, patients receiving haemodialysis may exhibit behaviors such as not accepting their condition and refusing medical nutrition therapy until the symptoms of non-adherence to diet become intolerable (15). Depending on the amount of food consumption in patients receiving haemodialysis, some important disorders may occur in the fluid-electrolyte balance (16).

One of the serious complications related to nutrition in HD treatment is hyperpotassemia, which is usually due to excess intake of potassium in the diet (3, 17). Although hyperpotassemia develops due to several reasons such as some drugs used in dialysis treatment, intra and extracellular potassium movements, metabolic acidosis and constipation, excessive potassium intake with diet continues to be the main factor affecting the serum potassium level (18). However, the balanced replacement of foods with high potassium content in the diet and with those with low potassium content necessitates a regular and detailed nutritional education (19). Practical approaches such as nutritional education are needed in patients receiving haemodialysis who have problems adherence to their diet (20). Nutrition education given to patients receiving haemodialysis has an important effect on increasing the effectiveness of treatment and the quality of life. These educations help patients to better understand their condition and increase the effectiveness of HD treatment (21). In nutrition education about potassium, patients should be told what potassium is, what function it has in the body, and how much potassium standard portions of food contain. In these educations, patients should also be informed that food additives or nutritional supplements contain significant amounts of potassium (22). In a study in which nutrition education was given to patients receiving haemodialysis, serum potassium level decreased significantly after education (10). On the other hand, Noori *et al.* (2010) monitored patients receiving haemodialysis for five years but found no significant relationship between dietary potassium intake and serum potassium levels (23).

One-on-one and face-to-face education is one of the most widely used methods of nutrition education

given to patients (24). This education method is a patient-oriented approach and plays an important role in increasing the patient's knowledge level of the disease (25). Patients educated with this method learn the necessary information by discussing with the researcher. In this way, positive behavioral changes are observed in terms of adherence to diet and the level of knowledge about various minerals that are important in the nutrition in HD treatment increases (26). Baraz *et al.* (2010) reported that the one-on-one nutrition education given to patients receiving haemodialysis positively affected their adherence with diet and fluid restrictions (27). Ebrahimi *et al.* (2016) stated that one-on-one and face-to-face nutrition education given to patients receiving haemodialysis increased the general knowledge level about minerals such as sodium, phosphorus and potassium (28).

In our study, the patients given the individual nutrition education were informed about what hyperpotassemia is, the importance of dietary potassium and the side effects of excess potassium intake during HD treatment. This education given to the patients by the researcher was one-on-one and face to face nutrition education.

In our study, the mean pre-education potassium knowledge score of the patients in the intervention group was 33% of the maximum score to be obtained from the overall questionnaire used to measure their potassium knowledge levels. In the same group, after the entire education process, this rate reached a level as high as 73%. However, no significant change was observed between the pre- and post-education scores of the patients in the control group. The comparison of the intergroup changes demonstrated that while the difference between the intervention and control groups before the education was not statistically significant, there was a 35% difference between the two groups after the education. The findings obtained from our study proved that the nutrition education improved the participants' knowledge of potassium. Similarly of our study, Dağdeviren & Savaşer (2003) found that nutritional education given to patients receiving haemodialysis resulted in a 30% increase in their potassium awareness score (10). Tsai *et al.* (2016) who investigated the effect of the nutrition education given by the dietitian on the patients receiving haemodialysis' knowledge of some minerals determined that their knowledge level significantly increased after the education (29). In another study, Ford *et al.* (2004) reported that nutrition education given to patients receiving haemodialysis improved their adherence with dietary principles in HD treatment and that the patients' level of knowledge about hyperphosphatemia increased by 9% after the education compared to their pre-education level (30).

Before the first nutrition education, serum potassium levels were similar in both groups. However, after the education, the mean potassium levels of the patients in the intervention group decreased by 11%, which was significantly different from that of the patients in the control group. While the mean pre-education serum potassium levels of the patients in the intervention group were in the risky range (5.81 mEq/L; > 5.5 mEq/L), they decreased to physiological range (5.15 mEq/L; 3.5 - 5.5 mEq/L) after the education. In the control group, these values remained in risky ranges (5.81 mEq/L and 5.60 mEq/L, respectively > 5.5 mEq/L) before and after the first education.

After the first nutrition education given to the patients in the intervention group, their mean serum potassium level decreased significantly (12%), compared to their pre-education serum potassium level. In the control group, there was no difference between their serum potassium levels measured before and after the first education. The second education was aimed at strengthening the patients' knowledge of hyperpotassemia. In order to find out whether the nutrition education was effective, the difference between serum potassium levels measured before the first education and those measured after the second education was determined. In the participants in the intervention group, this difference was greater (15%) than the difference measured after the first education. However, the difference in the participants in the control group was not significant. In a study in which the effects of nutrition education given to patients receiving haemodialysis on some of their biochemical parameters were investigated, the education was held as group education in 4 sessions lasting for a month, and the face-to-face nutrition education was supported by video presentations. In the same study, post-education serum potassium level decreased greatly (32%) compared to

the pre-education level (31). In the present study, face-to-face nutrition education was not supported by video presentation, which probably limited the amount of decrease in serum potassium levels.

In a similar study, the effects of nutritional education on serum electrolyte levels in patients receiving haemodialysis were examined. In this study, it was observed that serum potassium levels were statistically significantly lower after nutrition education (32). Garagarza *et al.* (2015) gave individualized nutrition education to patients receiving haemodialysis and it was observed that the number of patients with risky serum potassium levels (>5.5 mEq/L) decreased after the education (33). On the other hand, Aghakhani *et al.* (2017) reported that the nutrition education given to patients receiving haemodialysis did not make a significant difference in serum potassium levels (34).

In a study conducted with patients receiving haemodialysis with hyperphosphatemia, as in our study, the effect of repetitive nutrition education on serum phosphorus values was investigated. In that study, after the first nutrition education, while the average phosphorus values decreased by 23% in the intervention group, no significant decrease was observed in the control group. However, after the second education, the serum phosphorus mean value differed significantly neither in the intervention nor in the control group. In that study, each education period was designed to be 4 months (35). The fact that each education period of our study was designed as 1 month seems to have led to the difference in serum levels after the second education, because the prolonged education process can reduce the participants' interest in the subject and prevent them from following the subject carefully.

In our study, the intragroup mean serum potassium levels of the participants in both groups were analyzed before and after the nutrition education. In the intervention group, potassium levels decreased significantly in both of the nutrition educations. In the control group, post-education serum potassium values did not differ from the pre-education ones in the second nutrition education as in the first education. Repeating the nutrition education lowered the serum potassium level averages more in the intervention group. The effects on serum potassium levels did not disappear in a short time and appeared in the long term with the repetition of the education. According to Karamanidou *et al.* (2008) if the education given to patients receiving haemodialysis is not repeated, it will not lead to behavioral changes and its effectiveness will be limited (36). Jo *et al.* (2017) found that repetitive nutrition education given to patients receiving haemodialysis significantly reduced serum potassium levels (37). In our study, it is thought that the repetition of the nutrition education contributed to an even more decrease in the serum potassium values at the end of the second education.

As a result of the literature review, many studies have been found that investigate the nutritional education given to patients receiving haemodialysis and the effects of this education on diet adherence and nutritional status. However, it has been observed that there are a limited number of studies that include a potassium-specific nutrition education, especially given to adult patients receiving haemodialysis, and the effect of this education on serum potassium level (38). In our study, the effect of nutrition education given to patients receiving haemodialysis treatment on serum potassium levels was investigated. In conclusion, our study provides new data to the literature and highlights the lack of information in the field.

Limitations of the study

In the selection of the patients, the randomization process was not performed completely, patients who underwent HD treatment on Monday, Wednesday and Friday were assigned to the intervention group, and those who underwent HD treatment on Tuesday, Thursday and Saturday were assigned to the control group. The days were determined by the HD center. The HD center did not have a separate place where patients could receive one-on-one education. Therefore, visual education materials other than the handbook could not be used, and thus the effectiveness of the nutrition education was not enhanced by using various educational materials such as food catalogs, food replicas, and audio-visual tools. The study was conducted in a single center and the number of the participants, although the sample was calculated, was small to reach a definitive judgment.

Conclusions

In conclusion, it has been observed that a nutritional education about potassium reduces serum potassium levels in patients receiving haemodialysis. In addition, an increase was observed in potassium knowledge scores as a result of nutrition education given to patients receiving haemodialysis. In our study, it has been shown that face-to-face and one-on-one nutrition education is effective in maintaining serum potassium levels within physiological ranges. Thus, it has been shown that regular and scheduled individual nutrition education in haemodialysis centers is a convenient method to reduce the incidence of hyperpotassemia.

Authors' contributions: Mehmet Çavdar: Principal project leader, conceived study, participated in design and coordination, applied nutrition education, read and approved the final manuscript; Habibe Şahin: Participated in design and coordination, helped to draft manuscript, read and approved the final manuscript, analysed the data.

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