Introduction: Urolithiasis is one of the most frequent urinary tract clinical entities worldwide. A plethora of factors contribute to its pathogenesis, thus creating a broad field for research and study. This review focuses on the assessment of the existing diet questionnaires in order to bring out the possible effect dietary factors may have on urolithiasis pathogenesis.

Methods: The method used in order to locate studies which dealt with renal calculi and dietary factors was a search in PubMed literature database from January 1997 to March 2017.

Results: The search has revealed studies which employed Food Frequency Questionnaires (FFQs), Load of Acid to Kidney Evaluation (LAKE) screening questionnaires as well as non-specialized questionnaires. Most of the studies used an FFQ, a recall method of food intake within a specific length of time. The analysis of their results has brought forth significant correlations, such as the higher risk of the formation of stones as a result of increased salt consumption. Additionally, the Potential Renal Acid Load (PRAL) of foods has been strongly associated with the risk of renal calculi and can be easily estimated using the LAKE screening method.

Conclusions: The Food Frequency Questionnaire has been revealed as the primary choice of questionnaire type in order to examine the association of dietary parameters with renal calculi. The analysis of the questionnaires has displayed significant correlations of dietary factors with urolithiasis, which may direct towards its treatment as well as the prevention of relapses. The LAKE score constitutes an easy, fast and inexpensive way to study the effect diet has on the calculus-forming potential, which may assist in patients’ individualized approach.

Abstract

**Key words**

questionnaires; dietary factors; urolithiasis; urinary stone disease

1. Introduction

Urolithiasis is a common urological condition which afflicts both men and women at a 2:1 ratio. Chances of a relapse are approximately 50%, while within a decade, they can reach as high as 70%. The risk factors include age, maleness, genetics, environment as well as dietary habits. In-
deed, the role that diet has in urolithiasis pathogenesis and relapse proves to be very significant. In this light, several dietary questionnaire-based studies have been conducted. The present review is aimed at comparing and contrasting the existing diet questionnaires and evaluating the possibility of applying the insight they offer in order to pinpoint the dietary factors that lead to urolithiasis [1].

2. Methods

The bibliographic search that was conducted using PubMed database specified sources dating from January 1997 to March 2017, with the use of the following keywords: “questionnaire”, “nutritional intake”, “dietary factors”, “renal stone disease”, “urolithiasis”, “urinary stone disease”, “kidney stones” and “renal calculi”.

3. Results

The aforementioned search yielded twenty articles (Table 1). Following the analysis of the method applied in the respective research studies, it was found that thirteen of these were based on FFQs, that is, Food Frequency Questionnaires (2-10,12-15), one suggested the LAKE screening questionnaire[16], which specially evaluates the potential load of acid to kidney, and the remaining six used a non-specialized questionnaire type, formed by the researchers depending on the specific aim of each study and the number of the respondents to whom it was administered [1,17-21]. In terms of the Greek facts, two more studies were found which, however, were based on questionnaires that did not include the entirety of the dietary factors. The first one was published in 1999 and used FFQs of only 36 types of foods [2], whereas the second one was published in 2006 and was limited to the role of water consumption [1] (Table 1).

3.1 Food Frequency Questionnaires (FFQs)

Food Frequency Questionnaires (FFQs) are the typical method for the collection of nutritional information concerning the risk of renal calculi. However, a mention should also be made to the rest of the available methods, which are classified into two categories, as follows:

1. Occasional or frequent nutritional intake recall methods

The collected information depicts the last 24 hours (24-hour dietary recall) or the frequent nutritional choices of an individual within a defined amount of time (dietary history, FFQ).

2. Dietary food record methods

In this case, the participants are asked to record the foods and drinks they consume in real time during the course of a day (24-hour food record) or more days [22].

More specifically, FFQ is defined as a questionnaire in which the respondent is presented with a list of foods and is required to say how often each is eaten in broad terms such as x times per day/per week/per month, etc. [23] (Figures 1, 2).

During the selection of the elements used in the FFQs, a common technique was the pointing out, with the use of other available elements, of the usually consumed foods (such as representative population sample food availability elements). An alternative to this was the use of the already existing and tested questionnaires. The number of the food items in the FFQs differed immensely. The dietary factors were examined as either single items or food groups. According to Cade et al., in order to evaluate a causal connection (diet to urolithiasis), it is preferable to have a comprehensive food list enabling computation of the full range of nutrients rather than a restricted list to determine the intakes of a few nutrients [23].

The consumption frequency was recorded using multiple-choice questions (respondents selected their answer from a series of suggested answers), a method which increases clarity and reduces the possibility of errors, compared to the open-ended questions (no answers are suggested; respondents themselves are called to define the frequency with which they consume certain foods) [24].

The frequency categories varied in number, with 12 being the highest.

Some of the FFQs were semi-quantitative, that is, the questions on frequency included sub-questions regarding the amount of the consumed foods [25]. The recording of the consumed foods was achieved either through familiar measurement units, or through food models or photographs.

Several FFQs were self-administered whereas others were interviewer-administered. It is a given that one-to-one interviews are likely more advantageous in the sense that they allow clarifications during the questionnaire completion, yet the possibility of systemic error increases, due to the respondents’ lack of anonymity [26].

In addition, it was evident that prior to the use of FFQs, most of them were examined regarding their repetability, otherwise reproducibility, and all of them were examined regarding their validity. More specifically, their
repeatability was evaluated during the FFQ administration twice on a representative sample of the total study sample. In order to test validity, the principal role was held by calibration, a process during which the information gathered through the FFQ was associated with the respective numbers of another method (reference method), which had been applied on a representative sample. One or more of the following methods were used as the reference method: dietary history, 24-hour dietary recall and nutritional intake biochemical indicators.

Nevertheless, according to Cade et al., there are cases in which the FFQ use is not suggested: 1) small-sample studies, 2) the use of an FFQ that was designed for a specific country unless the two countries share quite similar dietary habits [23].

### 3.2 Results of FFQ studies

Listed below are the most important dietary factors and their association with urolithiasis, as they emerged after the analysis of FFQ-based studies, which were discovered after literature research.

#### 3.2.1 Calcium

A number of six questionnaires looked into the association of dietary calcium intake with the risk of nephrolithiasis, and it was found that its increased intake has a protective action. The mechanism explaining these findings is the reduction of oxalic acid excretion with urine since it is
bound to the calcium in the gastrointestinal tract. Nonetheless, in two of these studies it is evident that calcium supplements do not reduce the risk of nephrolithiasis; on the contrary, they might even increase it. In three of the questionnaires, there was not an association of dietary calcium intake with nephrolithiasis, whereas in another questionnaire, there was a positive association, that is, increased calcium intake via diet increases the risk of urolithiasis, a finding that comes in sheer contrast with the rest of the results [2,4-9,13-15].

### 3.2.2 Animal proteins

Five of the questionnaires examined the association of dietary animal protein intake with the risk of nephrolithiasis. From the analysis of the results deriving from one of the questionnaires, no correlation emerged. Conversely, the rest of the studies displayed a higher risk of nephrolithiasis if dietary animal protein intake is increased. A possible mechanism is an increase in uric acid levels, hypercalcinuria and a drop of urine pH that animal protein causes, creating a predisposition for forming calcium oxalate stones and mainly uric acid crystals. However, one of the studies found that the increase in animal protein intake resulting in increased risk of nephrolithiasis only occurs to males with Body Mass Index (BMI) less than 25 kg/m², a finding which currently has no explanation [2,5,6,9,10].

### 3.2.3 Fruits and vegetables

The results deriving from three of the questionnaires indicated that the increase in fruit and vegetable intake acts protectively against the formation of stones. Nevertheless, this finding requires further examination, due to the fact that the analysis of one of the questionnaires indicated a positive correlation between the increased intake of leafy vegetables such as spinach and green beans, with the risk of the formation of stones; in another study there was a link between increased fiber intake and the increased risk of urolithiasis [2,5,8,10,13].

### 3.2.4 Salt

An increase in salt consumption was connected to the high risk of the formation of stones [3]. This risk seemed to be greater in women who consumed more than 3,249 mg of salt daily. These findings are in conjunction with physiological studies indicating that increased salt intake results in increased salt and calcium excretion during kidney discharge [9].

### 3.2.5 Magnesium/Potassium/Zinc

The analysis of three questionnaires showed that magnesium has a protective action against urolithiasis, since the lack of magnesium in urine was a common finding in patients with urolithiasis. One of the studies, though, showed no statistical discrepancies in the magnesium intake between patients who suffered from urolithiasis and those who did not [4,6,10,13]. As far as the potassium intake is concerned, there was a question in two questionnaires in which it was evident that its increased intake protects against the formation of stones. The most possible mechanism is that reduced levels of dietary potassium intake increase the excretion of calcium during kidney discharge, which in turn increases the risk of the formation of stones [4,6]. The results of another questionnaire seemed to also inculpate zinc intake for stone formation [10].

### 3.2.6 Vitamins

Generally, there is a not yet documented belief that vitamins (especially vitamin C) act protectively against stone formation. The analysis of a questionnaire indicated higher levels of vitamin C intake in patients that were not suffering from urolithiasis than in those who did. However, other studies did not show a link between Vitamin C intake and renal calculi. Further examination is definitely required [4,6,8].

### 3.2.7 Liquids

As a general rule, high water consumption tends to protect individuals from urolithiasis. In fact, male patients who ingested more than 2,000 ml of water daily, had a 50% less chance of developing kidney stones when compared to those who only ingested less than 500 ml per day. Coffee intake was higher in patients with no kidney stones in two of the questionnaire results, while the same cannot be stated about tea, since the results were conflicting. However, another study indicated that coffee, natural juice and soda water have, in fact, no link with the protection against kidney stone formation. The same study indicates that alcohol consumption does not present differences between patients with urolithiasis and those without it, yet red wine showed a protective action, quite possibly due to its antioxidant activity. Finally, beer also seemed to protect against the formation of kidney stones [4,6,8,13].

### 3.3 LAKE Score

According to Lemann et al., acid load dietary intake may...
affect the way calcium is metabolized through a subsequent mild systematic acidosis, thus mobilizing the calcium in bones and increasing the renal discharge of calcium. On the other hand, the latent chronic acidosis might decrease the renal discharge of citrates, which are known to act as inhibitors in calcium crystal formation in urine [28].

Modern western countries’ diet includes the pronounced intake of components of acid precursors, causing a metabolic imbalance that may be involved in the pathogenesis of numerous diseases, including urolithiasis. In patients who tend to form calcium crystals, calcium excretion seems to depend more on the dietary acid load than the dietary calcium intake, while urine citrate depends immensely on dietary acid load [29,30]. The arising conclusion is that patients who suffer from urolithiasis and form calcium kidney stones should be advised to limit the dietary potential renal acid load (PRAL), in order to mitigate the risk of a relapse.

However, clinicians often fail to provide patients with proper diet guidance due to the lack of simple tools that would allow them to form a reliable dietary history [31]. A time-saving screening method of diet evaluation (LAKE score) was recently designed in order to provide a reliable evaluation of dietary PRAL in a short time [16].

The dietary screening LAKE (Load of Acid to Kidney Evaluation) instrument is a one-page questionnaire divided in two parts. The first part comprises eight items that represent the intake of acid-releasing foods, that is, meat, cured meat, cheese, eggs, milk and dairy, pasta and bread (positive LAKE subscore). The second part consists of five items designed to depict base-releasing foods, that is, potatoes, legumes, vegetables, fruit and juices. This screening method requires no software for the interpretation of the results, and the questionnaire can also be self-administered. Finally, it also includes a separate category for the consumption of sandwiches, which is marked positively when the sandwiches contain animal products, whereas it is marked negatively when they are vegetarian [16].

During the evaluation of this method, LAKE score classifies patients by approximating the estimations derived from the 24-hour dietary recall, which is the screening method for the dietary PRAL evaluation [32]. Thus, this fast, simple and inexpensive screening method for the evaluation of dietary PRAL could offer a typical picture of the diet of the patients suffering from urinary tract lithiasis, so as to allow an immediate suggestion regarding their diet during a doctor’s visit.

More specifically, according to Spearman rank correlation coefficient (r), the total LAKE score evaluates the respondents quite well in comparison to the dietary PRAL (r>0.50). There was also a great correlation of positive LAKE score with the total energy intake, the intake of proteins, lipids and phosphates as estimated from the 24-hour dietary recall. Negative LAKE score presented a good correlation with potassium and vitamin C intake, as estimated from the dietary recall [33].

Moreover, those who tested with “high” PRAL indexes (“high” acid load is defined as higher than 27.3 mEq/day according to the 24-hour recall) had a score above 0 in the LAKE screening method. 95% of those who scored 15 or more in the positive LAKE subscore marked a high protein intake according to the 24-hour recall (high protein intake is defined as 0.8 g/kg/day or more). Consequently, a LAKE score higher than 0 can be considered as an index of excessive dietary acid load while a positive LAKE subscore above 15 may indicate excessive protein dietary load [33].

PRAL can be calculated with the help of several methods, such as the 24-hour dietary recall and Food Frequency Questionnaires (FFQs). All these methods, each one with its advantages and disadvantages, are complicated and time-consuming and are not easy to be clinically applied. The availability of a fast method for the evaluation of the potential acid load in the diet can prove beneficial for the clinical evaluation and monitoring of patients. The correlations that were observed suggest that a LAKE score can offer reliable PRAL estimations, similar to the ones derived from the 24-hour dietary recall. If there is an interest in studying the intake of protein, calcium and potassium in order to estimate the risk of stone formation, the positive and negative LAKE subscores provide exceptional estimations of these nutritional substances. Clinicians can use the LAKE score as a fist-stage classification, in order to provide their patients with information regarding their condition, as well as diet-related advice. Patients with a high total LAKE score would be able to receive an extensive evaluation and guidance from a dietitian. Yet, the effectiveness of the LAKE screening method is based on the fact that it includes the most important food elements, according to the dietary habits of most individuals who live in Italy (the development and evaluation of the method was based on population that resides in Italy), and thus it might be less suitable for people who live in other countries. Therefore, this model should be confirmed with greater population and also popula-
tions with different dietary habits and models [33].

4. Conclusions
In most epidemiological nutrition studies, the hierarchical classification of individuals depending on their usual dietary intake is enough in order to estimate correlations between diet and diet-related diseases. For this reason, FFQs, providing a valid picture of dietary intake, are the primary choice for the examination of the correlation between dietary parameters and the incidence of diet-related diseases. Furthermore, the fact that the questionnaires can be easily completed by the patients themselves and the lower cost than other methods of dietary estimation, such as the dietary history and the 7-day food record, are among some of the advantages of the FFQs.

The analysis of the results of the questionnaires has indicated significant correlations between dietary parameters and urolithiasis, which can offer guidance towards its treatment and prevention of a possible relapses.

The LAKE score offers reliable estimations of the potential dietary acid load and can be utilized as a screening method, in order for patients to be provided with information regarding the state of their diet and advice for its modification, while patients with high total LAKE score can be referred to specialized dietician.

Conflicts of interest
The author declared no conflict of interest.

References
6. Taylor E., Stampfer M., Curhan G. Dietary Factors and the Risk of Incident


