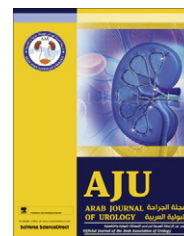




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REVIEW

Stone formation in the Middle Eastern Gulf States: A review

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KEYWORDS

Urolithiasis;
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Oxalate;
Calcium;
Uric acid;
pH;
Urine volume

ABBREVIATIONS

CaOx, calcium oxalate;
CaP, calcium phosphate; UA, uric acid;
GNI, Gross National Income; GDP, Gross Domestic Product;
KSA, Kingdom of Saudi Arabia; UAE, United Arab Emirates;
P_{SF}, the biochemical probability of stone formation

Abstract Objectives: To review the possible causes of the high incidence of urolithiasis in the oil-rich Gulf States.

Methods: Data were extracted from published reports on the incidence of urolithiasis, affluence and diet in the Gulf States, various Western countries and China.

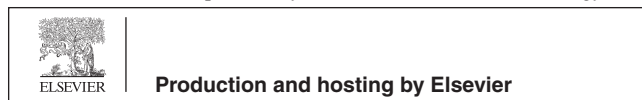
Results: There are strong relationships: (a) between the life-expectancy of stones in men and the Gross National Income (GNI) per capita of these countries; and (b) between the daily consumption of animal protein and GNI per capita. Together these data suggest that the occurrence of stones is proportional to the intake of animal protein, although they also indicate that there are additional factors that further increase the risk of urolithiasis in the populations of the Gulf. The consumption of oxalate in the Gulf is three times higher and that of calcium a half of what it is in Western countries. Thus, the average oxalate/calcium ratio in the intestines of the Gulf populations is five to six times higher than that in Western populations, leading to enteric hyperoxaluria and an increased risk of calcium-oxalate stone formation. The risk is further accentuated by the lower urine volumes, due to the hot, dry climate of the region, and lower excretions of citrate, from the highly acidic urine resulting from the high intake of animal protein. There is a high incidence of uric acid-containing stones from the acidic urine and the hyperuricosuria caused by the high intake of purine.

Conclusions: The high incidence of urolithiasis in the Gulf is due to an adverse combination of dietary and environmental factors.

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Introduction

Urolithiasis is a disorder that is recognised throughout the world, although its incidence varies widely amongst countries [1]. In general, the incidence of kidney stones has been shown to be relatively low in developing countries which have low levels of Gross Domestic Product (GDP) and economies that are dependent mainly on agriculture, but the incidence is higher in the wealthy industrialised countries with high levels of GDP. In the UK there is a strong relationship between the incidence of stones and affluence at three different demographic levels [2]. The highest recorded incidence of upper urinary-tract stones appears to be in the oil-rich states of the Arabian or Persian Gulf, such as the United Arab Emirates (UAE) [3], Kuwait [4] and Saudi Arabia (KSA) [5], where the main types of stones consist of calcium oxalate (CaOx) and/or uric acid (UA) [6,7]. On the other hand, the populations of the countries in this region have fewer calcium phosphate (CaP)-containing stones and fewer infection stones than are reported from most Western countries (Table 1).

In the present article the main risk factors for CaOx and UA stones in the wealthy countries of the Middle East will be reviewed and a hypothesis developed as to why these types of stone formation are so common in that part of the world.

Methods

Data on the life-time expectancy of the forming stones in men were calculated from various publications on urolithiasis in the oil-rich countries of KSA [5,8], Kuwait [4,9] and the UAE [10], and in various countries in the West [1]. Data on international per capita daily food consumption [11–16] and national levels of affluence [17] were taken from previous reports. Data on the 24-h urine composition of men in the Middle East and in the West were taken from published data [3,18]. To be consistent in terms of time, the studies were limited to data collected within the period 1980–90.

Results

The life-time expectancy of stones in men and the effect of affluence

Data on the life-time expectancy of men in various countries forming at least one stone by the age of 70 years in relation to the annual Gross National Income (GNI) per capita in these countries are shown in Fig. 1. (The GNI per capita of a given country is based on the purchasing power parity rate of the GDP per capita in that country calculated in international dollars by the World Bank. This allows for differences in national prices and taxes and is a measure of the relative purchasing power of the per capita income in each country expressed in international dollars, where 1 international dollar = 1 US dollar in 1980). In this review therefore GNI per capita has been used in preference to GDP as a real measure of affluence, as it corrects for variability in purchasing power between countries.

The data in Fig. 1 were extracted from numerous published sources and relate to the international economic situation between 1980 and 1990 [1,4,5,8–10,17]. The stone incidence data from China were reported before the recent rapid rise in industrialisation and in the GNI per capita of that country, and it is highly likely that urolithiasis is now much more common there than in the 1980s. Figure 1 shows, first, that the incidence of stone disease in a given country is almost linearly related to the level of affluence in the population up to an annual GNI per capita of ≈\$16,000 (based on 1980–90 data), and then the relationship begins to flatten. Secondly, Fig. 1 shows that during that period urolithiasis was extremely common in all of the main oil-rich countries of the Gulf region. How does affluence affect the risk of forming stones?

Affluence and diet

Numerous studies have shown that locally, nationally and internationally the main dietary factor that is correlated with the level of affluence in the population is the consumption of animal protein, in particular the

Table 1 The percentage occurrence of different stone types according to the predominant mineral in Kuwait, the KSA, the USA and the UK and between 1975 and 2004.

Predominant mineral (%)	Kuwait (2004)	KSA (1989)	USA (1975)	UK (1975)
UA	15.5	14.6	10.1	4.5
CaOx	73.0	71.3	58.8	53.3
CaP	9.5	7.6	20.3	30.9
Magnesium ammonium phosphate	1.0	3.7	9.3	9.6
Rare (cystine, etc.)	1.0	2.8	1.5	1.7

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