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Do Weather Conditions Influence the Onset of Renal Colic? A Novel Approach to Analysis

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Key Words

Renal colic · Temperature · Humidity · Calculi · Climate

Abstract

Background/Aim: To investigate the seasonal variations of the incidence of renal colic by a computerized analysis of cyclic climatic features. ***Methods:*** 1,163 consecutive patients with acute renal colic were studied. Eigendecomposition and signal reconstruction of district temperature and humidity were performed to establish any cyclic variation. Average temperatures and humidity values were calculated at time periods of 15, 30, 45 and 60 days preceding each renal colic. ***Results:*** Patients were allocated to groups every 30 days, since eigendeanalysis suggested that intervals of this duration have homogeneous climatic features. With an average time period of 15 days preceding each renal colic, a positive correlation coefficient of temperature (r = +0.75 with CI 0.31–0.93, $p < 0.005$) and a cubic relationship at the regression analysis (R = 82.4%, p = 0.015) were found with the onset of colics. We observed a negative correlation between humidity and renal colic (rho = –0.70 with CI –0.92 to –0.21, $p < 0.01$), with an inverse relation as regression model (R = 57.9%, $p < 0.05$). ***Conclusions:*** We demonstrated an association between the onset of renal colics and exposure to hot and dry weather, particularly when temperatures rose above 27°C and relative humidity fell below 45%.

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Introduction

The worldwide occurrence of urolithiasis is estimated at around 1–6.6% with the likelihood to form stones depending on the geographical location: 1–5% in Asia, 5–9% in Europe, 13% in North America, and 20% in Saudi Arabia [1–3]. Many factors have been suggested to contribute to the occurrence of renal stones, including diet, water hardness, geographical location, race, occupation, sex, and climatic conditions [4–6].

It makes sense that exposure to a hot climate without adequate water consumption may result in dehydration, and the consequently concentrated urine promotes an increase in urinary crystallization [7–10]. There is no wide consensus about the seasonal influence on the incidence of renal colics in the literature [11–16].

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The aim of the present study is to carefully investigate the influence of the climatic conditions on the incidence of renal colics in a large patient cohort.

Methods

Population Evaluated

We retrospectively reviewed the records of 1,163 consecutive patients evaluated at the Emergency Department of the University Hospital of Padova because of a renal colic in 2003. We collected from each patient the date of hospital admission, sex, and age. The inclusion criterion was a proven renal colic due to calculi; the diagnosis was made on the basis of clinical history, physical examination, urinalysis, ultrasound examination and an abdominal plain X-ray film. In doubtful cases intravenous urography or spiral computed tomography were performed. Only patients who were residents in the Padova district were included in this study.

We collected the records of 733 males (63%) and 430 females (37%). The males formed a group of patients with a median age of 43.4 years (25th to 75th percentile: 34.8 and 53.7 years); for the females the median age was 37.4 years (25th to 75th percentile: 27.3 and 51.1 years). The age difference between these subpopulations was significant ($p < 0.0001$).

Climatic Features of the Padova District in 2003

The Padova district is located in northeastern Italy (longitude 11° 52′; latitude 45° 24′; altitude 12 m above sea level).

From the Regional Agency for Environmental Prevention and Protection in Veneto (ARPAV) we obtained the following climatic parameters: daily minimum, medium and maximum relative humidity (respectively, H_{min}, H_{med}, H_{max}) measured as a percentage value, and the daily minimum, medium and maximum temperature (respectively, T_{min}, T_{med}, T_{max}) measured in degrees centigrade. The data encompassed a period of 420 days, starting in November 2002 until the end of December 2003.

To evaluate the presence of cyclical trends of the variability of the temperature and humidity patterns, we used the eigendecomposition (TableCurve 2D v5.01© 2002, SYSTAT Software) throughout the study period of 420 days. Using eigendecomposition filtering and signal reconstruction in the time domain, it was possible to isolate individual oscillatory components in the scanned signals such as temperature and humidity patterns (i.e. cyclical variations) [17].

For each patient we computed the average values of humidity and temperature of the climatic exposure over a variable time interval immediately preceding the renal colic. The durations studied were 15, 30, 45 and 60 days before the renal colic, reflecting the prior climatic exposure of each patient.

Statistical Analysis

Parametric continuous variables were expressed as mean value ± standard deviation and 95% confidence interval for the mean (CI), and nonparametric continuous variables were expressed as median and interquartile ranges (25th to 75th percentile). The statistical analysis employed a Kolmogorov-Smirnov test to assess whether the distributions of values did or did not approximate a normal gaussian curve; a variance analysis was done with the F test. To define the degree of association between the quantitative continuous casual variables we performed a Bravais-Pearson's product moment correlation (r) or Spearman rank order correlation (rho) depending on the shape of data distribution.

Regression analysis and F test were done to analyze the variance. In each statistical analysis, a two-sided $p < 0.05$ was considered statistically significant. Statistical analyses were performed using MedCalc for Windows, version 7.6.0.0 (MedCalc Software, Mariakerke, Belgium).

Results

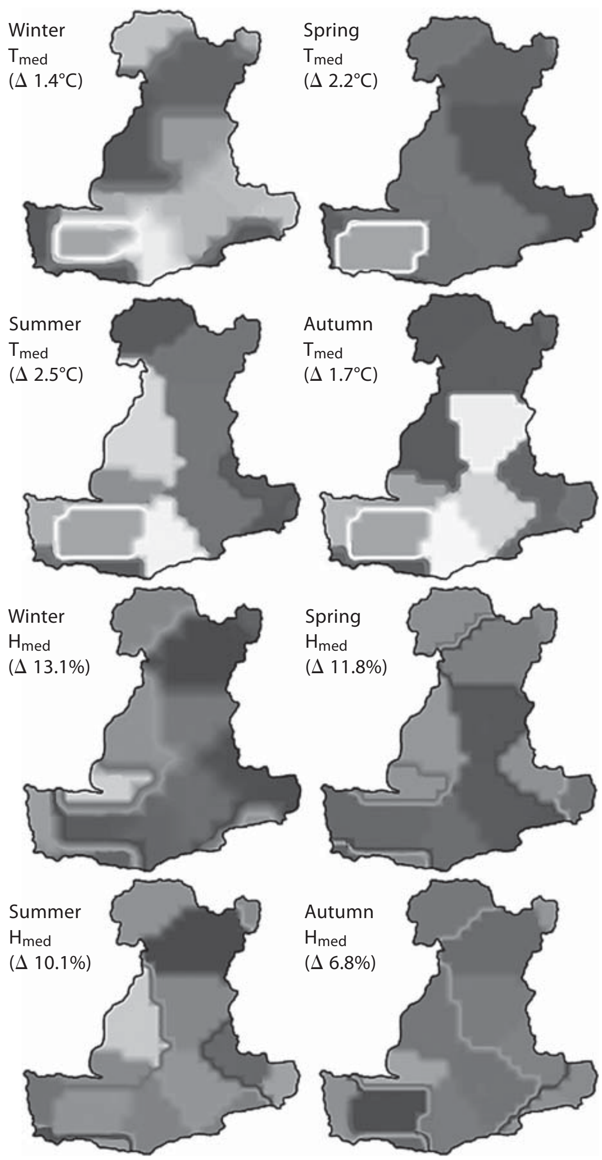
The climatic data registered in 2003 are summarized in figure 1 and table 1.

Eigendeanalysis decomposed both the thermometric signal and hygrometric curve on basic constituents. The greatest signal component identified a seasonal trend which covered the entire observation period (fig. 2). Among the other resulting components, we excluded the first annual component corresponding to climatic variations on a yearly basis, and grouped the ones from the 2nd to the 4th order which represented the higher weight parts on the graphic pattern corresponding to climatic variations with cycles shorter than 1 year. Their reconstructed signals expressed a time period of 30 days. We excluded all the other signal components with an order higher than the 4th, and so excluded the bias of minimal cyclic changes.

Consequently, we considered a 30-day period as a homogeneous climatic phase, to which we could allocate patients with a colic episode because of their comparable climatic exposure. This data process permitted us to improve the sensitivity of our correlation studies.

Correlation and Regression Studies

We investigated whether there was an association between the number of episodes of colicky flank pain and temperature and humidity pertinent to the days preceding the colic. With regard to the relationship with the temperature, we considered T_{min}, T_{med} and T_{max} average values. Results are shown in table 2. The detected correlation was greater for T_{max} than the ones emerging by analysis against T_{min} and T_{med} in an independent way from the time period adopted to calculate the average temperature values (table 2). Furthermore, the association was stronger considering a climatic T_{max} exposure focusing on the last days preceding the renal colic (time period of 15 preceding days, $r = +0.75$ with CI 0.31–0.93, $p < 0.005$), but became weaker when looking at a longer time period



Seasonal average values (2003)

	T_{min}	T_{max}	T_{med}	H_{min}	H_{max}	H_{med}
Winter	0.6	7.8	4.2	60.5	92.5	76.5
Spring	7.8	19.5	13.7	40.7	91.8	66.2
Summer	19.4	32.6	26.0	37.2	93.5	65.3
Autumn	8.6	17.1	12.8	60.4	95.3	77.8

Fig. 1. Seasonal average temperatures (T_{med}) and humidity (H_{med}) variances recorded in the Padova district in 2003. Fluctuation range is reported (Δ), grey-scaled color changes reflects temperature variations (darkest = coldest) or humidity variations (darkest = wettest). Temperatures are expressed in degrees Celsius, while relative humidities are reported as percent values. Seasonal computation is as follows: winter (Dec–Feb), spring (Mar–May), summer (June–Aug), and autumn (Sep–Nov).

Table 1. Monthly average values measured all over the Padova district in 2003

	Monthly average values (2003)					
	T_{min} °C	T_{max} °C	T_{med} °C	H_{min} %	H_{max} %	H_{med} %
January	–0.2	6.6	3.2	68.3	96.0	82.1
February	–2.4	8.1	2.8	34.9	85.1	60.0
March	3.1	15.2	9.1	40.8	91.5	66.1
April	7.0	16.6	11.8	46.1	92.8	69.4
May	13.4	26.7	20.0	35.2	91.1	63.2
June	19.2	32.1	25.6	40.2	95.2	67.7
July	18.5	31.3	24.9	38.1	93.5	65.8
August	20.4	34.4	27.4	33.4	91.7	62.5
September	12.2	24.9	18.6	38.4	93.2	65.8
October	7.6	16.4	12.0	54.2	93.5	73.8
November	6.7	12.9	9.8	71.7	96.3	84.0
December	1.5	8.3	4.9	61.9	93.4	77.6

before the colic, and weaker still with a period of observation of 60 days (time period of 60 preceding days, cases logarithmic conversion, r = +0.59 with CI 0.03–0.87, $p < 0.05$), as shown in table 2 and figure 3.

With respect to the correlation with the humidity, we considered the average values of H_{min}, H_{med}, and H_{max}. The detected correlation was greater for H_{min} than the ones emerging by analysis against H_{med} and H_{max} in an independent way from the time period adopted to calculate the average temperature values. Results are shown in table 2. Moreover, the link was stronger considering a climatic exposure focusing on the last days before the stone episode (time period 15 preceding days, rho = –0.70 with CI –0.92 to –0.21, $p < 0.01$), but became weaker adopting a longer time period before the colic, reaching the lowest value with an observational period of 60 days (time period 60 preceding days, rho = –0.58 with CI –0.87 to –0.01, $p < 0.05$), as shown in figure 3.

To identify some possible regression models describing our collected data, we applied the regression studies to the 15-day time period, because it had the strongest correlation with the variables considered. Focusing on the variables T_{max} and renal colic, we found a cubic relationship as a regression model (R = 82.4%, p = 0.015, 'knee' at 27°C) (fig. 4).

Furthermore, focusing on the variables H_{min} and renal colic, the regression model identified an S relationship (R = 57.9%, $p < 0.05$, slope at H_{min} 45%) (fig. 4).

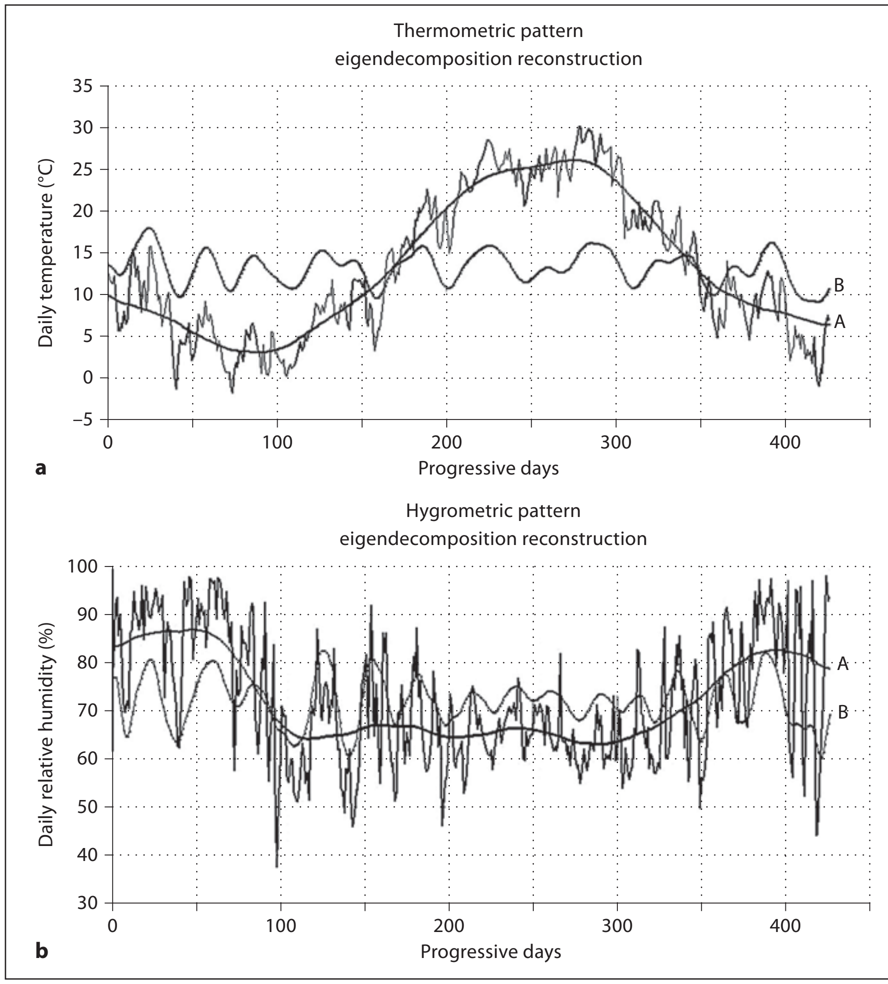


Fig. 2. Eigendecomposition and reconstruction. Thermometric (**a**) and hygrometric (**b**) patterns are shown (thin line). The reconstructed signal components were marked as: the strongest signal constituent (curve A) and the harmonics constituents (from 2nd to 4th) useful to detect a subannual cyclic variation (curve B).

Table 2. Correlation coefficients between renal colics and climatic features

Computing time periods	Renal colics and T_{max}		Renal colics and T_{med}		Renal colics and T_{min}	
	correlation coefficient r (CI 95%)	p	correlation coefficient r (CI 95%)	p	correlation coefficient r (CI 95%)	p
15 days	+0.75 (0.31–0.93)	<0.005	+0.74 (0.28–0.92)	<0.01	+0.72 (0.26–0.92)	<0.01
30 days	+0.70 (0.20–0.91)	<0.05	+0.67 (0.16–0.90)	<0.05	+0.65 (0.12–0.89)	<0.05
45 days	+0.65 (0.12–0.89)	<0.05	+0.62 (0.08–0.88)	<0.05	+0.60 (0.04–0.87)	<0.05
60 days	+0.59 (0.03–0.87)	<0.05	+0.57 (–0.01–0.86)	0.05	+0.54 (–0.04–0.85)	0.068
	Renal colics and H_{max}		Renal colics and H_{med}		Renal colics and H_{min}	
	correlation coefficient r (CI 95%)	p	correlation coefficient rho (CI 95%)	p	correlation coefficient rho (CI 95%)	p
15 days	–0.04 (–0.60–0.54)	0.89	–0.56 (–0.86–0.02)	0.06	–0.70 (–0.92–0.21)	<0.01
30 days	–0.20 (–0.70–0.42)	0.52	–0.59 (–0.87–0.03)	<0.05	–0.69 (–0.91–0.21)	<0.05
45 days	–0.18 (–0.69–0.44)	0.57	–0.57 (–0.86–0.01)	0.06	–0.66 (–0.89 to –0.13)	<0.05
60 days	–0.16 (–0.67–0.46)	0.62	–0.46 (–0.82–0.15)	0.13	–0.58 (–0.87 to –0.01)	<0.05

The computing time periods varied in length from 15 to 60 days before the colic. CI = Confidence interval at 95%.

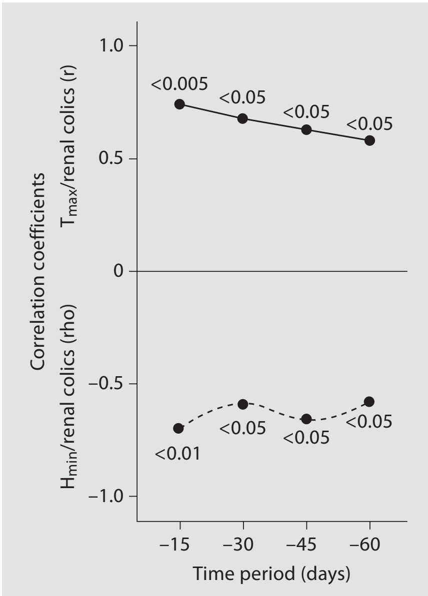


Fig. 3. Relation strength between climatic factors and stone episodes: influence of the time period observed. x-axis expresses the length of time for which climatic data were studied before each colic. p values are shown at each time point for each correlation coefficient.

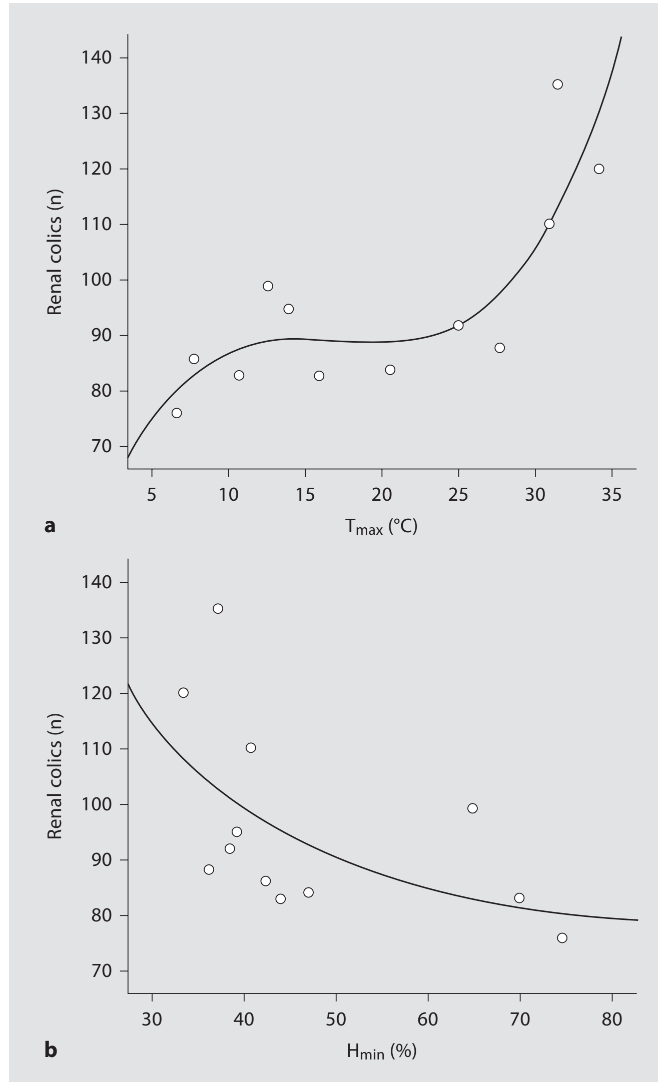


Fig. 4. Regression model of the relation between renal colics (observational time period 15 days) and T_{max} (**a**) and H_{min} (**b**).

Discussion

The use of a statistical analysis based on data preliminarily obtained from a large patient cohort by a novel approach using eigendecomposition and signal reconstruction proved the association between the occurrence of renal colic and some climatic features. We established a positive correlation versus maximum recorded temperature (hottest days) and a negative correlation versus minimum registered humidity (driest days), with a stronger relation for the average values observed during the last 15 days leading up to the colic. This suggested a heavier influence of the last climatic exposure on the occurrence of the colic. In the past an increase in episodes of renal colic due to dehydration was seen, with a consequently increased urinary concentration [10]. Inadequate liquid ingestion to compensate sweating results in a low urine volume and represents one of the main risk factors for lithogenesis [18, 19]. These factors can play a role in speeding up the stone-forming process, and so precipitate a subclinical lithogenic condition into an overt renal colic.

Against this theoretical background, and upheld by the evidence that the incidence of renal colics was greater in a hot and dry environment, it is possible to interfere with this process by adequate hydration when the temperature rises above 27°C and relative humidity falls below 45%, as this is associated with a marked increase in renal colics.

There is still an open debate on the real influence of a hot climate on the incidence of renal colic. Studies performed in Japan, Saudi Arabia, Iran, England and Wales underlined an association between a higher incidence of renal colic and the hottest months of the year [7–10, 12, 13, 16, 20, 21]. Prince and Scardino [22] reported a peak incidence of urinary colics in July, August and September on average 1–2 months after the peak of maximal monthly mean temperature in the study area.

In contrast, a study done in Iraq found a correlation with autumnal months, and a Norwegian one established an association of renal colics with winter and autumn months [1, 14]. An analysis performed in Kuwait and one done in a Swedish district showed no relation with seasonal variations [11, 15].

To understand the reason for the heterogeneous results reported in the literature on this topic, we figured out that by selecting 'a specific month in a certain area' as term of comparison, a 'qualitative' evaluation was introduced, which is not comparable with other months or different regions.

Whenever the temperature was reported, it was referred to the data collected on the corresponding colic day for every patient. If we view the stone-forming process as a disease in shaping, we have to consider for every patient the days preceding the renal colic; indeed we evaluated different time periods (from 15 to 60 days) before each renal colic.

Whenever the mean value of an exposure temperature is reported, it is referred to the average temperature of the month in which the colic occurred, disregarding evidence that a patient having a colic in the last days of a month had been exposed to the average temperature of the same month, while a subject with a colic in the first days of the same month had been exposed to the average temperature of the preceding month [5, 14]. Other authors simply referred to an association of a higher frequency of stone episodes with a particular season or month, without supporting their finding with any temperature measurements [1, 11, 16], or reporting only an approximate difference (i.e. 10°F) against a not well-defined temperature of the continental United States [23].

Moreover, when we consider the climatic influence of seasonal variations on renal colics, we refer to the thermometric changes and to the humidity as a major sweating determinant. Some authors approached this issue investigating the rainfall in the month preceding the colic [5]. Only Fujita [21] evaluated the relative humidity linking the stone event to the climatic data recorded on the same day, therefore diverging from our approach.

Data obtained from the records provided by the emergency department did not allow us to evaluate the degree of dependence between variables linked to the onset of the renal colic. This represents a limitation of this study.

Conclusions

This study showed a clear association between the incidence renal colic and climatic features, with a direct relationship with the maximum temperature and an inverse relationship with the minimum humidity. We suggest adequate hydratation when the temperature rises above 27°C and relative humidity falls below 45%, as these factors are associated with a marked increase in renal colics. Moreover, we found a major influence of the climatic features of the 15 days preceding each ureteric colic on the specific clinical event. This correlation becomes weaker as the considered climatic exposure preceding a renal colic increases in length.

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