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Research paper

# Seasonal influence on the renal function in hospitalized elderly patients

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ABSTRACT

*Background:* Elderly adults are more vulnerable to heat-induced illness because of dysfunctional thermoregulatory mechanisms, chronic dehydration, medications, and diseases involving the systems that regulate body temperature. We hypothesized that extensive loss of fluids in a hot and dry climate in the summer months may lead to impaired renal function in elderly patients. The aim of the study was to determine the impact of the season of admission on renal function and the development of acute kidney injury in elderly patients.

*Methods:* A retrospective observational cohort study on all patients older than 65 with creatinine level $\leq$ 2.0 mg/dL who were hospitalized twice (in the summer and in winter) in 2010–2011. The outcome was incidence of acute kidney injury.

*Results:* The study cohort included 1107 consecutive patients hospitalized in the summer and in the winter months. The biochemical parameters of impaired renal function were more prominent in the summer as compared to the winter months in the whole cohort of patients and especially in patients with hypertension, diabetes mellitus and heart failure, and in patients treated with thiazide diuretics, ACE-inhibitors and ARBs. The most common reason for hospitalization in patients developing AKI in the summer was febrile disease and sepsis and in the winter heart, failure.

*Conclusions:* Extensive fluids loss in a hot and dry climate in the summer months leads to mild impaired renal function in elderly patients. However, this influence is not clinically significant probably due to compensatory mechanisms for the preservation of renal function.

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## 1. Abbreviations

| | |
|---|---|
| ACE-I | Angiotensin converting enzyme inhibitors |
| ADH | Antidiuretic hormone |
| ARBs | Angiotensin receptor blockers |
| AKI | Acute kidney injury |
| GFR | Glomerullar filtration rate |
| CHF | Congestive heart failure |
| COPD | Chronic obstructive pulmonary disease |
| DM | Diabetes mellitus |
| IQR | Inter quartile range (25th percentile; 75th percentile) |
| RAAS | Renin–angiotensin–aldosterone system |

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## 2. Introduction

One of the most serious problems of the 21th century is global warming. Since the early 20th century, earth's average surface temperature has increased by about 0.8 °C (1.4 F), with about two thirds of the increase occurring since 1980. Climate model projections indicate that during the 21st century, the global surface temperature is likely to rise a further 1.1 to 2.9 °C (2 to 5.2 F) for their lowest emissions scenario and 2.4 to 6.4 °C (4.3 to 11.5 F) for their highest [1]. There is a dearth of data on the influence of this warming trend on human health.

The climate of southern Negev in Israel is very hot and dry, especially in the summer period and therefore, it is an advantageous place to study the effect of high temperatures on human health.

Elderly debilitated patients are especially sensitive to the influence of environmental factors on their health [2,3]. Also, older adults are more vulnerable to heat-induced illness than younger people because of dysfunctional thermoregulatory mechanisms, chronic dehydration, medications, and diseases involving the systems that regulate body temperature [4].

When core temperature rises, the hypothalamus initiates corrective measures. The processes that produce body heat, such as shivering and chemical thermogenesis, are inhibited. Simultaneously, renal and splanchnic vasoconstriction and peripheral vasodilation occur, shunting blood to the periphery. Heart rate and cardiac output increase to distribute large quantities of blood to the skin where heat is dissipated. Sweating increases and facilitates the loss of even more heat through evaporation [4].

Age dependent decline in cardiac reserve and an age-related reduction in vascularity decrease peripheral blood flow and reduce the efficiency with which heat can be removed. When such conditions as hypertension, atherosclerosis, and heart failure are present, the body's ability to respond to heat is compromised further. It is a clear that in these conditions, the renal function may be impaired due to blood redistribution and diminishing of renal blood flow. Increased sweating in hot weather in elderly patients requires a good hydration, adequate water intake and urine concentrating ability. Without these conditions, elderly patients may to develop additional renal function impairment [4–6].

Early detection of heat illness and prompt treatment are crucial to survival in this population of peoples [3,4,7,8].

In addition, several factors predisposed elderly patients to water depletion and dehydration: a decrease of functional status with limitation of mobility, visual problems, confusion or other cognitive alterations, certain medications that greatly increase dehydration risk, such as diuretics, laxatives, and sedatives, all acute pathologies with fever and those that cause difficulties in swallowing or provoke diarrhea and/or vomiting [3,9]. Also, a fear of incontinence leads some elderly people to diminish their intake of fluids [3].

The following risk factors of water depletion and dehydration were identified in a study among acutely ill nursing home residents: female gender, age $>$ 85 years, more than four chronic conditions, more than four medications, bedridden status, laxative use, chronic infections [10].

The number of deaths of elderly people that occurred due to dehydration during the heat wave of the summer of 2003 in Europe illustrates the importance of this problem [3]. Mortality associated with disturbances of water balance in the elderly may be as high as 40–70%, depending on the treatment [5,6].

Findings consistently support the conclusion that the elderly do not become as thirsty as younger persons following water deprivation and subsequently do not drink enough to rehydrate themselves [11].

Maintaining hydration is important because of the close relationship between cell hydration and cell function. Appropriate water and electrolyte concentrations are essential for proper metabolic function and survival [12].

Several changes that occur with aging in renal function predisposed to kidney injury by various environmental factors [13–15]. For example, insensible loss can cause consecutive dehydration, pre-renal azotemia and the development of acute kidney injury (AKI) in this population [3,14,15]. Structural as well as functional changes occur as the kidneys age. Nephrons are lost and/or remaining ones perform less effectively, and the glomerular filtration rate (GFR) decreases [16]. Lessened responsiveness to hormonal signals causes the kidneys to function less efficiently in concentrating urine and correcting water loss [11,16]. There is evidence that impaired renal response to vasopressin causes the kidneys to be less able to concentrate urine [16].

AKI has been reported among 2–7% of hospitalized patients and these rates are increasing due to the aggressive treatment of elderly patients and the impact of nephrotoxic medications and invasive diagnostic procedures [17–21].

Many elderly patients use for the treatment of hypertension and diabetes mellitus thiazide diuretics, ACE-inhibitors and ARBs [22–27]. These medications may provoke or aggravate dehydration, volume depletion and decline renal perfusion in predisposed elderly patients [28].

The aim of the study was to determine the impact of the season of admission (winter or summer) in hospitalized elderly patients on the development of impaired renal function and AKI.

## 3. Materials and methods

We performed a retrospective observational cohort study on all patients older than 65 with creatinine level $\leq$ 2.0 mg/dL who were hospitalized twice (in the summer and in winter) in 2010–2011 at Soroka University Medical Center.

In this study, we enrolled patients with serum level of creatinine less than 2.0.

The RIFLE classification is the current standard for stratifying renal injury and failure and gives 5 stages of AKI according to creatinine elevation:

- risk – 1.5-fold increase in the serum creatinine;
- injury – 2-fold increase in the serum creatinine;
- failure – 3-fold increase in the serum creatinine;
- loss – complete loss of kidney function for more than 4 weeks;
- ESRD – complete loss of kidney function for more than 3 months [29].

A creatinine level of less than 2 gives us a pool of patients ranging from normal kidney function to failure (groups 1–3) and excludes the loss and ESKD groups (complete loss of kidney function 4–5).

Patients were allocated to groups according to their seasonal hospitalization: "summer" or "winter" months of the year. In our study, the periods of the year were defined as a "winter" – November, December, January and February and as a "summer" – June, July, August and September according to significant difference in temperatures in these periods of the year in southern Israel. The exclusion criteria were diagnosis of previously known renal insufficiency and creatinine level $>$ 2.0 mg/dL before the hospitalization. The clinical and biochemical characteristics of patients hospitalized in the summer months were compared with those hospitalized in the winter months. For estimation of renal function and diagnosis of AKI in the winter period, we used comparison of renal function in admission to the hospital

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