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ARTICLE

Association between use of air-conditioning or fan and survival of elderly febrile patients: a prospective study

G. Theocharis · G. S. Tansarli · M. N. Mavros · T. Spiropoulos · S. G. Barbas · M. E. Falagas

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Abstract Elderly individuals are more susceptible to excess summer heat. We sought to examine whether the use of cooling systems (air-conditioning or fan) affected the clinical outcomes of elderly febrile patients. We prospectively followed elderly (≥75 years old) febrile patients requesting the medical services of the SOS Doctors (a network of physicians performing house-call visits) from July 10 to August 20, 2011. Patients who used cooling systems ("users") were compared with those who did not ("non-users") regarding mortality, clinical outcome of primary illness (improvement or deterioration), and emergency hospitalization. Prospectively collected data were available for 339 individual elderly febrile patients. "Users" had lower mortality (10 % vs. 19 %, $p<0.05$) than "non-users"; no difference was noted on clinical improvement (85 % vs. 76 %, $p=0.11$) and emergency hospitalization rates (21 % vs. 30 %, $p=0.16$). No difference was noted between users of air-conditioning and fan regarding mortality or clinical improvement, but fan use was associated with more hospitalizations (37 % vs. 19 %, $p<0.05$). On multivariate analysis (assessing daily ambient temperature, use of cooling systems, patient age, and living conditions), the sole variable significantly associated with mortality was the non-use of cooling systems [odds ratio (OR): 2.18, 95 % confidence interval (CI): 1.06–4.50]. The use of air-conditioning or fan during hot summer periods appeared to be beneficial for elderly febrile patients living in a large city. Large prospective studies are warranted in order to provide further insight into potential individual and public health initiatives aiming to alleviate the impact of excess summer heat on the health of elderly patients.

G. Theocharis · T. Spiropoulos · S. G. Barbas
SOS Doctors, Athens, Greece

G. S. Tansarli · M. N. Mavros · M. E. Falagas (✉)
Alfa Institute of Biomedical Sciences (AIBS), 9 Neapoleos Street, 151 23, Marousi, Athens, Greece
e-mail: m.falagas@aibs.gr

M. E. Falagas
Department of Internal Medicine—Infectious Diseases, Mitera Hospital, Hygeia Group, Athens, Greece

M. E. Falagas
Department of Medicine, Tufts University School of Medicine, Boston, MA, USA

Introduction

The elderly comprise a large social group which has been steadily increasing over time. Greece is the fourth largest country in the world among major nations with regard to people aged 65 years and over; 19.1 % of the total population was ≥65 years old in 2008 [1]. Every summer, many deaths are attributed to high temperatures. Summer 2003 was the warmest of the last several years and a landmark for Europe regarding the impact of excessive heat on mortality. France, Italy, and Portugal were among the countries most affected by the high temperatures that had been recorded [2–4]. Several studies have indicated an association between temperature extremes and mortality [5, 6]; elderly individuals appear to be more vulnerable to temperature variations than younger people [2, 5, 7, 8]. Heat-related mortality appears more excessive in Mediterranean than in North European cities [8] and is mostly attributed to respiratory diseases [9]. A previous study [10] suggested that elderly individuals of an urban, Mediterranean population carried higher morbidity and mortality in August compared with November. This fact could be attributed to the excessive heat, an additional burden on their overall weakened health status. In regard to infections, studies have shown that elderly patients with infections experience higher mortality than younger age groups with the same infections [11–13]. Therefore, the impact of heat on elderly

febrile patients, among whom fever in the majority is attributed to infections, is expected to be greater than that on the general population.

In this context, we aimed to prospectively examine whether the use of a cooling system [air-conditioning (A/C) or fan] by elderly patients during a febrile episode is associated with favorable clinical outcomes.

Methods

Study design and patient population

We conducted a prospective observational study evaluating elderly (≥75 years old) febrile patients who called the SOS Doctors (a network of physicians who perform house-call visits) in Attica, Greece, from July 10th to August 20th, 2011. A febrile episode was documented based either on their presenting complaints or on the assessment of the attending physician. An oral informed consent was obtained by the participants in the study. The study was approved by the Ethics Committee of the SOS Doctors.

Data collection

Data concerning age, gender, living conditions (alone or taken care of by family, friends, or a maid), date, time of phone call and major complaint, use of a cooling system (A/C) or fan), outcome of the primary illness, medical diagnosis, and emergency hospitalization were collected. Medical diagnoses were classified into three groups: (1) infections (any infection was eligible), (2) other diseases (any disease excluding infections), and (3) unclear diagnosis.

Definitions and outcomes

No uniform definition for "febrile" was used; a patient was considered to be febrile according to his/her complaints at presentation or to the individual assessment of each attending physician. Patients who used cooling systems (A/C or fan) were defined as "users" and those who did not as "non-users". Patients who possessed a cooling system but did not use it were classified as "non-users". The maximum temperature ("Tmax") was defined as the maximum daily ambient temperature measured at Elefsina meteorological station [14]. The outcome of the primary illness, assessed 1 week after the initial patient examination by phone call by a secretary of SOS Doctors with the availability of a physician, was classified as improvement, stable, or deterioration (including death). Patients who remained stable during treatment were excluded from our analyses regarding outcome of the primary illness to avoid an inappropriate effect on our findings (since, depending on the underlying disease, a stable status may, in reality, represent a favorable outcome in some patients, but unfavorable in others).

The primary outcome of this prospective study was the all-cause, 1-week mortality. Secondary outcomes included the outcome of the primary illness (assessed at the follow-up call) and emergency hospitalization.

Data analysis and statistical methods

Univariate comparisons were performed to identify any difference in the patient characteristics between the two groups ("users" and "non-users"). Further analyses compared patients with regard to the primary and secondary outcomes.

Comparison of continuous variables (i.e., patient age and maximum daily ambient temperature) was performed using the *t*-test or the Mann–Whitney test (for normally and non-normally distributed variables, respectively). Categorical variables were compared using Chi-square tests. Variables potentially associated with mortality were included in a multivariate binary logistic regression model. The adjusted odds ratio (OR) and 95 % confidence intervals (CIs) were calculated. All analyses were performed with SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). A p-value<0.05 was considered to denote statistical significance.

Results

During the study period, the SOS Doctors received 2,626 phone calls; data were prospectively collected for 339 patients who were both elderly and febrile. "Users" [265 out of 339 (78.2 %); 133/265 (50.2 %) female] had a median age of 84 years, while "non-users" [74 out of 339 (21.8 %); 31/74 (41.9 %) female] had a median age of 82.5 (p=0.26). The patient characteristics and outcomes of "users" and "non-users" are presented in Table 1. No difference was observed in the baseline characteristics of the two groups.

Mortality

Users of cooling systems had lower mortality than non-users (10 % vs. 19 %, p<0.05). In addition, febrile elderly patients living alone had lower mortality than those taken care of by family, friends, or a maid (0 % vs. 13.4 %, p<0.05). No difference in mortality was observed between users of A/C and users of fan (11.3 % vs. 15.4 %, p=0.72). Table 2 presents the patient characteristics associated with mortality.

Outcome of primary illness and emergency hospitalization

The patient characteristics associated with the outcome of primary illness are presented in Table 3. No difference was

Table 1 Univariate analysis regarding patient characteristics and outcomes evaluated in "users" and "non-users"

Variable		Users, n=265 (%)	Non-users, n=74 (%)	p-Value
Age (median, interquartiles)		84 (79.50, 89)	82.50 (78.75, 87)	0.26
Gender (female)		133 (50.2)	31 (41.9)	0.24
Living alone[a]		30 (11.5)	8 (10.8)	>0.99
Diagnosis[a]	Infections	147 (56.1)	37 (50)	0.53
	Others	84 (32.1)	25 (33.8)	
	Unclear	31 (11.8)	12 (16.2)	
Tmax (median, interquartiles)		35 (34, 36)	35 (34, 36)	0.91
Call time	23:01–07:00	29 (10.9)	7 (9.5)	0.78
	07:01–15:00	94 (35.5)	24 (32.4)	
	15:01–23:00	142 (53.6)	43 (58.1)	
Emergency hospitalization		56 (21.1)	22 (29.7)	0.16
Outcome of primary illness[b]	Improvement	212 (85.1)	55 (76.4)	0.11
	Deterioration	37 (14.9)	17 (23.6)	
Mortality		27 (10.2)	14 (18.9)	0.046

[a]Data were not available for 3/339 patients, who were excluded from these analyses

[b]Data on patients whose outcome of primary illness was reported to be stable at the follow-up were excluded

observed between "users" and "non-users" regarding both secondary outcomes. Users of fan were more likely to be hospitalized than users of A/C (36.7 % vs. 19.4 %, $p<0.05$), but no difference was noted regarding the outcome of primary illness. The outcome of primary illness of elderly patients living alone was more likely to improve than that of patients taken care of by family, friends, or a maid (97.4 % vs. 76.5 %, $p<0.05$).

Multivariate analysis

The results of the multivariate analysis are presented in Table 4. Use of cooling systems, age, Tmax, and living conditions were the variables entered into the logistic regression model. Only non-use of cooling systems was independently associated with higher mortality (adjusted OR=2.18, 95 % CI: 1.06–4.50).

Discussion

The main finding of our study is that the use of a cooling system (A/C or fan) by elderly febrile patients during hot summer months was associated with lower mortality. More so, the only variable independently associated with lower mortality was the use of a cooling system. There was no difference in mortality between users of A/C or fan, but users of A/C had fewer hospitalizations.

This is the first study to our knowledge observing an association between the use of cooling systems and elderly febrile patients' survival. Several studies have addressed the effect of temperature on elderly mortality; it has been established that both excess cold [5, 15, 16] and excess heat [2, 7, 8, 17] significantly increase the mortality of elderly individuals. The excess heat-attributable mortality of elderly persons has been quantified for many European cities: in

Table 2 Univariate analysis comparing patient characteristics with regard to mortality

Variable		Died, n=41 (%)	Survived, n=298 (%)	p-Value
Use of any cooling system (A/C or fan)		27 (65.9)	238 (79.9)	0.046
Cooling system[a]	A/C	26 (86.6)	205 (90.3)	0.72
	Fan	4 (13.3)	22 (9.6)	
Age (median, interquartiles)		84 (79, 88)	84 (81, 88.5)	0.59
Gender (female)		17 (41.5)	147 (49.3)	0.41
Living alone[b]		0 (0)	38 (12.8)	0.01
Diagnosis[b]	Infections	18 (45)	166 (56.1)	0.20
	Others	18 (45)	91 (30.7)	
	Unclear	4 (10)	39 (13.2)	
Tmax (median, interquartiles)		35 (34, 36)	35 (33, 35)	0.15
Call time	23:01–07:00	4 (9.8)	32 (10.7)	0.65
	07:01–15:00	17 (41.5)	101 (33.9)	
	15:01–23:00	20 (48.8)	165 (55.4)	

[a]Of the 265 patients using a cooling system, data on the specific cooling system (A/C or fan) were not available for eight patients, who were excluded from this analysis

[b]Data were not available for 3/339 patients, who were excluded from these analyses

Table 3 Univariate analysis comparing patient characteristics with regard to the outcome of primary illness

Data regarding the outcome of primary illness is reported herein for 321 patients, since patients whose outcome of primary illness was considered to be "stable" at the follow-up were not analyzed (n=18); "deterioration" also included patients who died (n=41)

[a]Data were not available for 3/321 patients regarding living conditions and 2/321 regarding diagnosis; those patients were excluded from these analyses

Variable		Improvement, n=267 (%)	Deterioration, n=54 (%)	p-Value
Use of any cooling system (A/C or fan)		212 (79.4)	37 (68.5)	0.11
Cooling system	A/C	186 (71)	31 (59.6)	0.77
	Fan	21 (8)	4 (7.7)	
Age (median, interquartiles)		84 (79, 88)	84 (80.75, 88.25)	0.64
Gender (female)		126 (47.2)	26 (48.1)	>0.99
Living alone[a]		37 (14)	0 (0)	0.02
Diagnosis[a]	Infections	154 (57.9)	23 (43.4)	0.02
	Others	76 (28.6)	26 (49.1)	
	Unclear	36 (13.5)	4 (7.5)	
Tmax (median, interquartiles)		35 (34, 36)	35 (34, 35)	0.36
Call time	23:01–07:00	29 (10.9)	4 (7.4)	0.37
	07:01–15:00	87 (32.6)	23 (42.6)	
	15:01–23:00	151 (56.6)	27 (50)	

Athens, nearly 2.5 % of the summer mortality of elderly persons (≥75 years) has been directly attributed to the heat from 1992 to 1996 [18]. Furthermore, several studies have reported that infections lead to higher mortality in elderly patients than in younger patients [11–13].

Our study suggests that the contribution of cooling systems in elderly febrile patients' survival is actually valuable. Most public places are now air-conditioned, but elderly febrile patients may be unable to access such places due to their weakened health status. The majority of elderly patients included in our study had a cooling system at home. However, it is important to be understood that all elderly should have a cooling system at home during heat waves. Previous studies examining risk factors for heat-related mortality among the elderly suggested that, among others, elderly people who had a working A/C system at home or visited an air-conditioned place during heat had lower heat-stress mortality [17, 19]. In addition, the use of fan was associated with a trend towards lower mortality in one of the aforementioned studies [19]. Likewise, the non-use of heating systems during cold winter months has been associated with higher mortality [20, 21].

No difference in mortality or the outcome of primary illness was observed between users of A/C and users of fans in our study, whereas users of A/C had fewer hospitalizations. The function of A/C is based on both cooling the air and regulating air humidity, whereas fans only produce airflow and work by evaporative cooling of sweat, without cooling the air [22]. Therefore, the beneficial effects of the use of A/C on elderly survival could be attributed to the decrease of humidity levels as well. Regarding fans, there is controversy in terms of their impact on mortality during heat. Some have supported that the use of fans may be beneficial [19], others that fans do not affect mortality [17], and others that fans could induce mortality when used in areas with high humidity during heat [23].

Table 4 Multivariate analysis of factors associated with mortality

Factor	OR	95 % Confidence interval	p-Value
Use of a cooling system	2.18	1.06–4.5	0.035
Tmax	0.85	0.7–1.0	0.083
Age	1.01	0.96–1.1	0.66
Care	NA	NA	>0.99

Tmax maximum temperature, *NA* not applicable

Patients who lived alone had lower mortality than those receiving care on univariate analysis; however, receiving care was not associated with lower mortality on multivariate analysis. Another prospective study on elderly people showed that men (and not women) who lived alone had higher mortality than those cared for by someone [24]. Our counterintuitive result on univariate analysis could reflect a better health status of the patients living alone compared to those receiving care. It is noteworthy that the same finding regarding care and mortality had also been observed in a previous study reporting on elderly patients [10].

The findings of our study should be interpreted in view of certain limitations. First, the available data on patient comorbidity was insufficient to appropriately adjust for this variable; therefore, it is possible that the observed difference in mortality might be attributed to a lighter burden of disease in the elderly patients who used cooling systems. In addition, the sample of the study may not be totally representative of the general elderly population, since all analyzed patients represent a primarily urban population. Lastly, the ambient temperature was measured at one meteorological station and might not precisely pertain to all patients living in different areas of Attica.

In conclusion, the use of cooling systems during summer months was independently associated with lower mortality in febrile, elderly patients living in a large city. Large studies

evaluating both the general population as well as specific subsets of elderly individuals are warranted in order to precisely document the contribution of cooling systems in the health status of elderly individuals during hot summer months.

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Conflict of interest None.

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