Original Article

The Effect of Temperature on Illness Severity in Emergency Department Congestive Heart Failure Patients†

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Abstract

Introduction: Previous studies revealed fewer visits for congestive heart failure (CHF) to emergency departments (EDs) in New Jersey, USA and fewer admissions for CHF to a Southern Indian and an Israeli hospital during warmer months. Using hospital admission rate for CHF as a marker for illness severity, we hypothesized that CHF would also be less severe in warmer months. Materials and Methods: This is a retrospective cohort study which included all ED visits from 1 January 2004 to 31 January 2006. We analysed the monthly CHF hospital admission rates. We a priori chose to compare the admission rates for the 4 warmest to the 4 coldest months. Results: Of a total of 136,347 ED visits, 1083 (0.8%) were accounted for CHF. Hospital admission rate was 55.8%. Although there was a statistically significant increase in ED visits for CHF during the colder months, the 4 warmer months from June to September had 1.15 times higher hospital admission rate than the 4 coldest months from November to February. Conclusions: Contrary to our hypothesis, we found a statistically significant increase in the percentage of CHF visits admitted to the hospital during the warmer months. This suggests that although there are less ED CHF visits in the warmer months, a greater percentage tend to be severe.

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Key words: Climate, Outcome, Precipitating factors

Introduction

Congestive heart failure (CHF) is one of the leading causes of morbidity and mortality around the world. It is estimated that more than 5 million people in the United States (USA) have CHF.[1,2] The annual number of deaths and hospitalisations resulting from CHF has increased steadily to reach almost 900,000 hospital admissions and 300,000 deaths per year in the USA.[3,4] The estimated prevalence of CHF in adults over the age of 75 years old is 10%, with a lifetime risk of almost 20%.[5]

Several precipitating factors for relapses for CHF have been identified.[3,6,7] These precipitating factors can be identified in more than 90% of patients.[6,8] Common factors include non-compliance with medications or inappropriate reduction of therapy, myocardial ischaemia or infarct, new onset arrhythmias (especially atrial fibrillation) and dietary indiscretion. Less common, but certainly well-known inciting factors include infection, diuretic resistance, and physical, emotional and environmental stress.[6,7]

In particular, high ambient temperature may positively affect cardiovascular responses of the body because elevated temperatures lead to peripheral vasodilatation, a decrease in systemic vascular resistance, an increase in cardiac output, and an increase in the production of plasma norepinephrine levels.[9-16] However, climate excesses such as a hot and humid environment, have also been proposed as a precipitating factor for CHF.[6,8]

Previous studies revealed fewer visits for CHF to various emergency departments (EDs) in New Jersey, USA and fewer admissions for CHF to a Southern India and an Israeli hospital during the warmer months.[17-19] Using the hospital admission rate for CHF as a marker for illness severity, we hypothesized that CHF would also be less severe in the warmer months. Examining the effect of temperatures on CHF severity may provide insight into precipitating factors for CHF.

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Materials and Methods

We conducted a retrospective cohort study of all patients diagnosed with CHF from 1 January 2004 to 31 December 2006 in the emergency department of University Hospital in Antalya, Southern Turkey. The study had the approval of the local Institutional Review Board in Antalya.

We used the primary ICD 10 code assigned to each visit, to obtain all patients with an ED diagnosis of CHF from the ED database programme, Mediacil® 2.3 (Akdeniz University Hospital, Antalya, Turkey).

The gender, age and date of the ED visit were entered into a Microsoft Excel® (Redmond, WA, USA) spreadsheet. We analysed the total number of visits to ED, ED CHF visits, and CHF hospital monthly admission rates. The number of visits was normalised for each month to account for the differences in the number of days in the months.

We obtained the monthly average temperature data of Antalya from the website of the Turkish State Meteorological Service (www.meteor.gov.tr).[20] We chose a priori to compare the visits and the admission rates for the 4 warmest to the 4 coldest months as was done in a previous study. We used the 2-tailed Student's *t*-test to test for statistical significance with alpha set at 0.05.

Results

Of a total of 136,347 ED visits during the study period, 1083 (0.8%) were diagnosed with CHF. Of the CHF visits, 51.8% were female with an average age of 69.6 ± 12.0 years. The hospital admission rate for CHF visits was 55.8%.

The total number of ED visits varied little by month. Figure 1 shows the ratio of total ED visits and CHF visits per month and average monthly temperatures. In particular, there were no statistically significant differences in the ratio of total normalised ED visits in the 4 coldest months from November to February (average temperature = 10.6ºC) compared to the 4 warmest months from June to September (average temperature, 26.4ºC) (Ratio, 0.96; 95% CI, 0.87-1.06; $P = 0.32$).

There was a statistically significant increase in ED visits for CHF during the colder months. Figure 1 shows the ratio of total CHF visits each month normalised for the length of month to the average number of CHF visits per month. The 4 coldest months had 1.42 times (95% CI, 1.28-1.51; $P = 0.001$) greater ED visits for CHF than the 4 warmer months. There were no significant age ($P = 0.56$) or gender ($P = 0.76$) differences for the coldest and warmest months.

There was a statistically significant increase in the hospital admission rate in the warmer months. Figure 2 shows the ratio of CHF admission rate each month to the average monthly CHF admission rate. The 4 warmer months had a 1.15 times (95% CI, 1.03-1.27; $P = 0.03$) higher hospital admission rate than the 4 coldest months. The peak in admission rates was delayed by approximately 2 months compared to the peak monthly temperatures. The monthly hospital admissions for CHF and the average monthly temperature are shown in Figure 3.

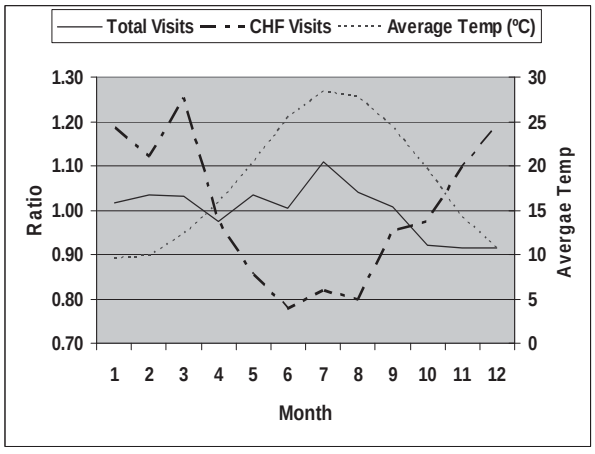

Fig. 1. Ratio of total monthly to average total monthly ED visits and ratio of CHF monthly to average CHF monthly visits and average monthly temperature.

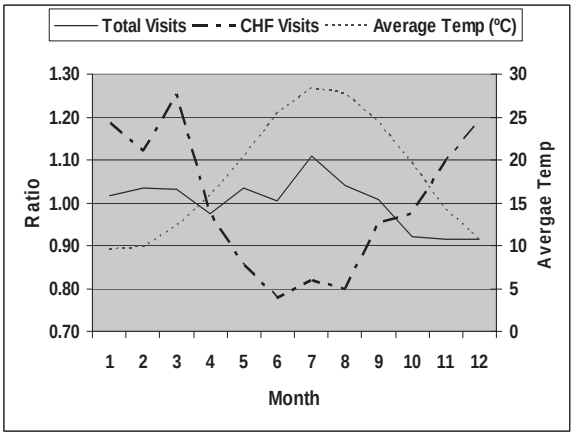

Fig. 2. Ratio of monthly to average monthly hospital admission rate for CHF and the average monthly temperature.

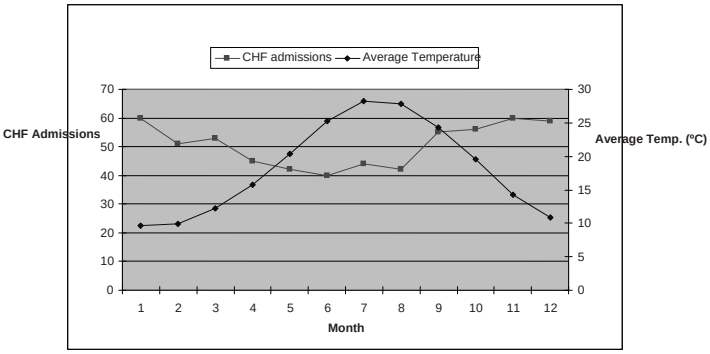

Fig. 3. Monthly hospital admissions for CHF and the average monthly temperature.

Discussion

We found a statistically significant increase in ED visits for CHF during the colder months. The 4 coldest months had 42% greater ED visits for CHF than the 4 warmer months. This difference was similar to that found in previous studies. Kitzis et al[19] reported significantly more hospital admissions for pulmonary oedema during the relatively cold winter and spring seasons in Israel (1.46 and 1.62 times greater than during the rest of the year). Balaji et al[18] found a 46% increase in CHF hospital admissions in the 4 warmest months compared to the 4 coldest months in Chennai, Southern India.Stewart et al in Scotland, Martínez-Sellés' et al and Boulay et al in France also reported significantly more hospitalisations for CHF in the winter.[21-23] Balaji et al[18] speculated that the increased work of the heart in cooling the body in high ambient temperatures may be more than offset by vasodilatation and decreased intravascular volume secondary to fluid loss from perspiration. Allegra et al[17] reported 35% more ED CHF visits in December than August in New Jersey, USA.They suggested that the increased CHF visits during colder months may be due to increases in the number of upper respiratory infections and increased catecholamine release in response to cold weather.[17]

Contrary to our hypothesis, we found a statistically significant increase in the percent of CHF visits admitted to the hospital during the warmer months. Our data suggest that, although there are less ED CHF visits in the warmer months, a greater percentage tend to be severe. It was unclear to us why the peak in admission rates is delayed by approximately 2 months compared to the peak monthly temperatures.

The results of previous studies regarding the effect of temperature on CHF are mixed. During exposure to a hyperthermic environment, systemic vascular resistance normally decreases due to cutaneous vasodilation. Cardiac output must increase to maintain blood pressure. Though the increase in cardiac output has been reported to be as high as 12 L/min in normal subjects during whole body heating, patients with CHF or coronary artery disease may not achieve an increase of cardiac output of 8 to 12 L/min.[10] During heat stress, the patient will either not maintain blood pressure or will not vasodilate the skin adequately for thermoregulation, the latter of which will increase the risk for heat-related injuries.[10,24]

Carroll[25] reported that patients with cardiovascular disease may not respond adequately to the increased demands caused by high temperatures. This risk was highlighted during the 1995 heat wave in Chicago in which 700 "excess" deaths were reported. Of deaths investigated, 39% had a prior heart condition.[26] Koken et al[27] also reported that higher temperatures appear to be an important factor in increasing the frequency of hospitalisation for acute myocardial infarction and CHF.

However, Schwartz arrived at a different conclusion. He investigated the effects of extreme temperatures on mortality by analysing 160,062 deaths in Wayne County, Michigan, among persons who were 65 years of age or older. He found that patients with diabetes had a higher risk of dying on hot days than other subjects, and persons with chronic obstructive pulmonary disease had elevated risks of dying on cold days. CHF, though, conveyed no higher risks than average.[28]

In the last 10 years, there have been several studies that favour the safety and efficacy of sauna bathing in patients with chronic heart failure.[12,15,16] Tei et al[12] demonstrated that a single 60ºC dry sauna bathing for 15 minutes was tolerable to CHF patients and produced beneficial acute haemodynamic effects, such as increase in cardiac output and decreases in systemic vascular resistance and pulmonary capillary wedge pressure via thermal peripheral vasodilatation. Miyamoto et al[15] reported that repeated sauna bathing was safe and improved symptoms and exercise tolerance in CHF patients. Kihara et al[16] emphasised that dry sauna treatment at 60ºC improves vascular endothelial function resulting in an improvement in cardiac function in 17 of 20 patients with CHF.

Since the effects of heat result in a decrease in episodes of acute decompensation of CHF, we also expected less severity of the condition in the warmer months as measured by the hospital admission rates. However, our results suggest that although ED CHF visits decrease in the warmest months similar to previous studies, the admission rate is significantly higher in the warmest months. We speculate that the greater number of upper respiratory infections and increased catecholamine release in response to cold weather may precipitate a number of milder cases of CHF.

There were a number of limitations in this study. Our study is based on ICD 10 codes, which may be biased by the physicians' habits with regard to assigning a diagnosis. We used the primary ICD code and in addition, we did not adjust for secondary diagnoses such as acute coronary syndrome, diabetes, renal insufficiency and hypertension. Also, there was not a standard admission criterion for CHF. The final ED decision to admit may be different among physicians. Our data also did not include information on the severity of illness. We used hospital admission rates as a proxy for severity of illness. There was no attempt to classify patients as to severity of illness using a standardised classification such as the New York Heart Association (NYHA) functional classification. We also lacked data on other precipitating factors, such as compliance with medication and dietary indiscretion. We did not change the assignment if the

hospital discharge diagnosis code differed from the ED diagnosis code. We do not suspect this will introduce any bias into our results.

Furthermore, we also did not have information on whether or not patients lived in climate controlled buildings. The data presented here may not be representative of all hospital EDs as this was a medical school university hospital. The seasonal patterns reflect the climate of southern Turkey and may not apply to other regions. We have used the monthly average temperatures in our study. If we had used daily or hourly temperatures with various lags and humidity we may have found other important factors. Lastly, there may be differences introduced by seasonal changes in the populations served by the emergency departments due to vacations.

Conclusion

Contrary to our hypothesis, we found a statistically significant increase in the percentage of CHF visits admitted to the hospital during the warmer months. This suggests that although there are less ED CHF visits in the warmer months, a greater percentage tend to be severe.

Acknowledgements

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