ORIGINAL ARTICLE

RISK FACTORS FOR HEAT RELATED DEATHS DURING THE JUNE 2015 HEAT WAVE IN KARACHI, PAKISTAN

Syed Ghazanfar Saleem, Tehreem Ansari*, Ashraf Shamshad Ali, Sara Fatima, Mariam Hassan Rizvi***, Muhammad Abdul Samad†**

Emergency Department, The Indus Hospital, Karachi, *Department of Medicine, Hamdard University Hospital, Karachi, **Department of Paediatrics, ***Department of Ophthalmology, Civil Hospital, Karachi-Pakistan, †Shaheen Research Group

Background: Mortality as a consequence of heat related illness is a public health concern. Emergency department (ED) experiences increased patients' flow and decreased survival as a consequence of heat stroke during the episodes of heat wave. The present study was conducted to identify the risk factors for mortality among victims of heat wave (17^{th} – 23^{rd} June), 2015 evaluated in the Emergency Department of The Indus Hospital (TIH), Karachi. **Methods:** In this cross-sectional study data was retrospectively collected. Out of 2278 patients, 150 patients who satisfied the inclusion criteria (core body temperature >38 °C, dehydrated and CNS dysfunction without infection) were included. Data was analysed using SPSS version 21 (IBM). **Results:** Among 150 patients included for analysis, the mortality was observed in twenty-four patients (16%). Majority (64.7%) of the patients included in this retrospective study were males and older with median age of 51.5 years. It was identified that non-survivors had significantly lower diastolic blood pressure and oxygen saturation compared to survivors along with higher median reparatory rate, pulse rate, temperature, and length of stay in emergency, shock index, and proportion of unconscious level. **Conclusion:** The study concluded that heat stroke patients with decreased diastolic blood pressure and oxygen saturation as well as patients with increased shock index, low conscious level and higher core temperature, respiratory and pulse rate should be considered for more intensive management in Intensive Care Unit (ICU) to decrease mortality rate during future heat stroke episodes.

Keywords: Emergency department; Heat stroke; Heat wave; Hyperthermia; Mortality; Pakistan; Karachi

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INTRODUCTION

Heat related illness occurs as a result of inadequate thermoregulatory response of body to preserve homeostasis. They are categorized as heat exhaustion or heat stroke.[1] Heat stroke is further classified as classic and exertional. Classic heat stroke develops gradually over several days with minimally raised core temperature for elderly patients with chronic disease. Clinical presentation includes central nervous system dysfunction (delirium, convulsion or coma) with core body temperature >40 °C and dry skin.[2] Exertional heat stroke primarily affects younger active population and is of more rapid onset developing in hours. It is frequently associated with high core temperatures. Heat exhaustion is more common heat related illness where core temperature lies between 37–40 °C. The symptoms include dizziness, weakness, thirst, headache and malaise.[2]

Mortality as a consequence of heat related illness is a significant public health concern since average global surface temperature continues to rise. Emergency department experiences increased patients' flow and decreased survival as a consequence of heat stroke during the episodes of heat wave. Heat waves and extended periods of extreme temperature have impacted the US Midwest in 1995 and 1999,[1–2] Western Europe in 2003 and 2006,[3–6] and Asia[7–8] in 1998 and 2003 with increased numbers of patients admitted in the emergency department and consequently high mortality. In the third week of June 2015, Karachi the most densely populated city of Pakistan experienced a devastating heat wave period. Temperature in the city went above 40 °C with highest maximum temperature recorded as 45 °C on 22^{nd} June. More than twelve hundred deaths were reported at government hospitals and private clinics. Majority of deaths were reported among male (69%), age greater than 50 years (74%) and homeless or living in home with limited electricity and water (60%).[9]

There is paucity of clinical studies that focuses on victims of heat wave triaged in the emergency department. The clinical risk factors for mortality are unclear. Indus Hospital, a tertiary care setting receives extensive heat wave victims during the heat wave period. High mortality was reported during that period at the Emergency Department (ED). The study aimed to identify factors associated with mortality in patients who were seen at the ED of The Indus Hospital during the heat wave period.

MATERIAL AND METHODS

In this cross-sectional study data was retrospectively collected based on records of all patients admitted to the

emergency department of Indus Hospital (Karachi, Pakistan) during the heat wave period June 17–23, 2015. Indus Hospital is a 150 bedded tertiary care hospital. The emergency department of The Indus Hospital (TIH) comprised 6 monitored beds and 2 resuscitation beds along with the 4 non-monitored virtual beds. During the heat wave period, the emergency department was extended to adjacent consultant clinics to accommodate the increase in patient flow. Medical records of 2278 patients received in the Emergency Department were reviewed by the principal investigator and co-investigator for the confirmation of diagnosis of heat stroke. The diagnosis of heat stroke was confirmed when both investigators reached the similar opinion. The inclusion criteria were core temperature ≥38 °C, dehydrated and central nervous system dysfunction without infection. Patients with incomplete medical records/non-sufficient medical evaluation due to premature departure or received as before death (BD) in emergency department were excluded. Demographic information (age, gender), clinical findings (systolic and diastolic BP, pulse rate, respiratory rate, temperature, oxygen saturation, conscious level), and laboratory data (Sodium, Potassium, Chloride, Bicarbonate, Creatinine and Urea) were recorded for all eligible patients. The shock index was calculated as ratio of heart rate and systolic blood pressure (heart rate/systolic BP/).[10] Data on length of stay in emergency and mortality as outcome of patient were also retrieved. Both clinical notes and laboratory findings were the initial values recorded. The maximum temperature (°C) and heat index during the heat wave period were also retrieved from the metrological department of Pakistan.[11]

A patient was diagnosed as dehydrated if the terminology "clinically dehydrated" or at least two of the following signs of dehydration (i.e., dry mucus membrane or axillae, sunken ocular globes and reduced skin turgor with prominent cutaneous skin folds) were available in the medical records.[12] Death during emergency department or hospital stay was considered criteria for mortality. Patients were considered infected if urine or blood culture within first 24 hours was documented positive or findings of chest x-ray within initial 48 hours were consistent with pneumonia. Diagnosis of malaria was confirmed on the presence of positive peripheral smear for malarial parasite.[12]

Study was approved by the institutional ethical review committee of The Indus Hospital (Study IRB Number: IRD_IRB_2015_11_007). Anonymity and confidentiality of the participants data was maintained throughout the research as no unauthorized person had an access to the identifiable patients' data. Data was analysed using SPSS-21. The proportions of categorical variables (i.e., gender and conscious level) were compared between survivors and non-survivors using *chi*-square test at 5% level of significance. If the assumptions of chi square were not satisfied Fisher's exact test was used. The Kolmogorov-Smirnov test was used to test the assumptions of normality for quantitative variables. As the assumptions were not satisfied Mann-Whitney U test was used to compare the median values between survivors and non-survivors. The quantitative variables were presented as median and interquartile range. For bivariate analysis p-value ≤0.05 was considered as significant.

RESULTS

During the heat wave period 17–23 June, 2015 the average temperature in Karachi was 41.2 °C. The maximum temperature of 44.8 °C was recorded on 20th June. Moreover, the heat index was more than 50 °C throughout the week with highest recorded on 20th June (66.1 °C). Figure-1 gives details of the maximum temperature and heat index during the heat wave period (17th – 23rd June, 2015) in Karachi.

Table-1 shows the comparison of demographic and clinical data between survivors and non-survivors. Among the patients included for analysis, the mortality was observed in 24 (16%). Majority 97 (64.7%) of the patients were males and older with median age of 51.5 years. Significant difference was found in median (25th percentile –75th percentile) in diastolic blood pressure [74 (63– 86) Vs. 62 (40–80.3); p-value =0.009], pulse rate [102.0 (91.8–120) Vs. 125.5 (102–139.3); p-value =0.013], respiratory rate [20 (20–22) Vs. 25 (20–30); p-value =0.003], temperature [38 (38–39.6) Vs. 39.1 (38.5–40.2); p-value =0.009], percent oxygen saturation [100 (94–100) Vs. 84.5 (75.8–100.0); p-value =0.005], shock index [0.82 (0.7–1.0) Vs. 0.99 (0.8–1.8); p-value =0.007] and unconscious proportion (19.8% Vs. 54.2%; p-value =0.001) between survivors and non survivors

Table-2 shows the comparison of laboratory findings of survivors and non-survivors. Significant difference was found in median (25th percentile–75th percentile) in Creatinine [1.3 (1.1–1.9) Vs. 1.8 (1.3–2.3); p-value =0.017] and urea [42 (30–74.3) Vs. 68 (47–100); p-value=0.002] between survivors and non-survivors. Patients who died had a significantly higher median creatinine and urea level.

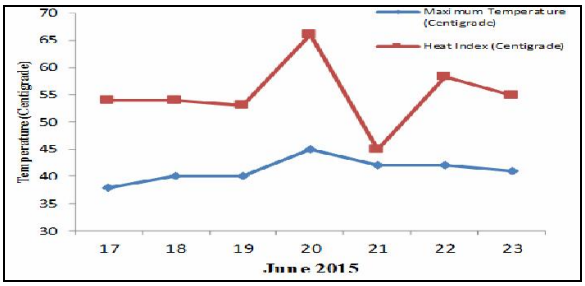

Figure-1: Maximum Temperature and Heat Index during the Heat wave period (17th – 23rd June, 2015) in Karachi

Table-1: Comparison of demographic and clinical data of Survivors and Non-Survivors

Demographic and Clinical data	Survivors (n=126)	Non-Survivors (n=24)	Total (n=150)	*p*-value
Age (years)	50.0 (39–61)	57.5 (45.8–70.0)	51.5 (40–63.5)	0.170
Gender				
Male	82 (65.1)	15 (62.5)	97 (64.7)	0.809
Female	44 (34.9)	9 (37.5)	53 (35.3)	
Systolic blood pressure (mmHg)	124.0 (100–144)	109 (62.5–139.3)	123 (100–143.3)	0.071
Diastolic Blood pressure (mmHg)	74 (63–86)	62 (40–80.3)	73 (61–85.3)	0.009
Pulse (beats/ min)	102.0 (91.8–120.0)	125.5 (102.0–139.3)	102.5 (92.0–123.0)	0.013
Respiratory Rate (Breath/ min)	20 (20–22)	25 (20–30)	21.5 (20–24)	0.003
Temperature (Celsius)	38 (38–39.6)	39.1 (38.5–40.2)	38.5 (38–39.6)	0.009
Spo_2 (%)	100 (94–100)	84.5 (75.8–100.0)	99 (89–100)	0.005
Conscious Level				
Conscious	101 (80.2)	11 (45.8)	112 (74.7)	0.001
Unconscious	25 (19.8)	13 (54.2)	13 (54.2)	
Shock Index	0.82 (0.7–1.0)	0.99 (0.8–1.8)	0.83 (0.7–1.0)	0.007
Length of stay in Emergency (hours)	5.92 (2.1–23.1)	2.6 (1.4–7.6)	5 (2.0–15.2)	0.009

Note: Results presented as frequency (percentage) for categorical data and median (25^{th} percentile – 75^{th} percentile) for quantitative data.

Table-2: Comparison of Laboratory data of Survivors and Non-Survivors

Laboratory Data	Survivors (n=126)	Non-Survivors (n = 24)	Total (n=150)	*p*-value
Sodium (mEq/ L)	138 (135–140.3)	138 (135–140)	138 (135–140)	0.968
Potassium (mEq/ L)	3.8 (3.5–4.1)	3.8 (3.1–4.8)	3.8 (3.4–4.1)	0.960
Chloride (mmol/ L)	100.5 (96–110)	99 (96–102)	100 (96.0–107.5)	0.378
Bicarbonate (mEq/L)	24 (22–24)	22 (22–24)	24 (22–24)	0.199
Creatinine (mg/ dl)	1.3 (1.1–1.9)	1.8 (1.3–2.3)	1.4 (1.1–1.9)	0.017
Urea (mg/ dl)	42 (30–74.3)	68 (47–100)	47 (34.5–81.5)	0.002

Note: Results presented as frequency (percentage) for qualitative data and median (25th percentile – 75th percentile) for quantitative data.

DISCUSSION

The results of 150 patients admitted in the Emergency Department of Indus Hospital during the heat wave period in Karachi from 17^{th} – 23^{rd} June, 2015 indicated that non-survivors had significantly lower diastolic blood pressure and oxygen saturation compared to survivors. Moreover, non-survivors had significantly higher median reparatory rate, pulse rate, temperature, and length of stay in emergency, shock index and proportion of unconscious level compared to patients who survived.

Patients included in this study were elderly (median age of 51.5 years) and predominantly males (64.7%). Previous studies have also reported that elderly age group with less dependency are more likely to be the victim of heat wave.[12,13] This population group is less likely to tolerate the high temperatures and use effective precautions to protect them. The present study reported a mortality of sixteen percent among heat stroke patients. The findings are comparable with previous studies conducted in Emergency Department. Hart et al in a clinical study conducted in 1982 reported mortality of 14% among patients with the diagnosis of heat stroke.[14] A retrospective analysis of 165 patients brought to the Emergency Department during the heat wave of August 2003 in France reported a slightly higher mortality (18.8%) at one month of follow-up.[12] To decrease mortality, patients with heat related illness should be identified early and triaged as early as possible. Elective management with cooling method is critical and should be initiated at earliest. Vicario *et al*. (1986) reported a lower mortality in rapid cooling group (15%) compared to the delayed cooling group (33%), thus signifies the clinical significance of early cooling to reduce mortality.[15]

The present study confirmed non-survivors had significantly high body temperature, breathing rate, shock index and decreased conscious level and significantly lower diastolic blood pressure compared to survivors of heat shock. The findings were consistent with previous clinical studies. The clinical study reported that elevated pulse and temperature, lower diastolic blood pressure, hypoxia, and decreased conscious levels were more frequent among non-survivors.[12] The median shock index for non-survivor was 0.99 which was significantly higher than survivors with a median shock index of 0.82. It is a valuable clinical parameter for the early recognition and evaluation of critical illness in the Emergency Department. Shock index ≥0.9 is a strong predictor of critical illness, priority at triage, more intensive therapy and admission at ICU. Compared to pulse and blood pressure alone, shock index (ratio of heart rate and systolic blood pressure) is a better indicator for evaluation of critical illness.[16] The present study reflected this in its findings and heat

stroke patients who died had a higher shock index (>0.9).

The findings of the present study highlighted that median sodium, potassium, chloride and bicarbonates were not significantly different between survivors and non-survivors and is consistent with the previous clinical study which also reported a non-significant difference.[12] The median values for the biochemical parameters were comparatively similar and lied within the normal range between both survivors and non-survivors. Moreover, the present study reported that significant difference was found in median of creatinine (1.3 Vs. 1.8; *p*-value=0.017) and urea (42 Vs. 68; *p*-value =0.002] between survivors and non-survivors with significantly higher urea and creatinine values in the later. Thus, heat stroke patients are at greater risk of mortality due to acute renal failure due to renal hypoperfusion and circulatory changes. The risk of mortality is aggravated in geriatric patient with chronic renal failure as co-morbidity. A retrospective study from South Australia reported increase in creatinine as poor prognostic factor for patients affected by heat wave.[17] In the present study, though urea and creatinine were significantly higher among non-survivors but creatinine values still lied within the normal limits, thus the findings should be interpreted with caution.

The study has few limitations. Being based on retrospective data, there were missing values for laboratory and incomplete notes. Such patients were excluded from analysis. Secondly, assessments at follow-up would have been clinically significant as in this retrospective analysis mortality during hospitalisation was only recorded. But on account of the quality of data available it was not possible. Thirdly, because of the smaller sample independent role of each risk factor could not be ascertained with confidence. In future, studies with larger number of patients from multiple clinical sites should be conducted to identify independent risk factors for mortality among heat stroke patients.

CONCLUSION

During the heat wave period emergency departments are over burdened with increased flow of patients and mortality remains high. Patients with hyperthermia, increased breathing, low diastolic blood pressure, increased shock index and decreased conscious level were at increased risk of mortality. Such patients should be considered for more intensive management in Intensive Care Unit (ICU) to decrease mortality rate during future heat stroke episodes. The study was helpful in identifying some criteria for ICU admission in case of another heat wave.

AUTHORS' CONTRIBUTION

GS conceptualize study, designed, data retrieval, did data analysis & writing of manuscript. TA conceptualize study, did literature search, data analysis, review, writing and final editing of Manuscript. AS did data retrieval, data analysis, and final review of manuscript. SF did literature search, data analysis, writing and final editing of manuscript. MH assisted in literature search, writing and final editing of manuscript. AS did data analysis, data interpretation and assisted in writing and final editing of manuscript

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Address for Correspondence:

Dr. Syed Ghazanfar Saleem, Consultant Emergency Department, The Indus Hospital, Plot C-76, Sector 31/5, Opposite, Korangi Crossing Road, Karachi-Pakistan
Cell: +92 333 305 3062
Email: Ghazanfar.saleem@tih.org.pk