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Abstract

Background: Climate change has heightened the threat of heat stroke in previously temperate zones.

Aims: This study aimed to assess the outcome of patients in relation to mortality and the role of effect modifiers among heatstroke patients presenting to a tertiary care hospital in Karachi during June 2015.

Methods: A retrospective observational study was conducted on heatstroke patients 20–27 June 2015 at the Emergency Room(ER) of a private hospital in Karachi, Pakistan. Patients' demographic data, disease severity, presentation and outcomes were determined. Statistical data was reported as numbers, percentages and mean ± SD.

Results: In total, 315 patients reported to ER; 76.6% patients survived, 23% expired. Males were 55% and 60% patients were fully mobile. Hypertension was the most frequent concurrent disorder. Fever documented in 79.4% and CNS derangement in 73.3% patients were the top most presenting features. Fever and disease severity were found to exert significant impact on disease outcome. Mortality rate dropped from 26 June onwards from 24.35% to 15.9% by using evaporative cooling technique combined with air conduction and maintaining room temperature at 22–24°C.

Conclusions: Poor outcome during heatstroke can be minimized by advance planning and

timely intervention in low- and middle-income countries.

Keywords: heatstroke, mortality, morbidity, climate change, Pakistan

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Introduction

Climate change has contributed to a paradigm shift in the lives of people with more episodes of heat-related illnesses being recorded and an average temperature increase of 0.8°C has been noted since the 20th century (1–3). In June 2015, the Islamic Republic of Iran was hit by a severe heat wave, believed to be the second highest with a recorded temperature high of 74°C, with an actual air temperature of 46°C and a high dew point temperature of 32°C (3). Both India and Pakistan endured major loses during that period, with fatalities reported to be 1400 and 1300 respectively (5,6). Karachi is a heavily populated city and suffered significantly due to a high heat index, urban island effect, frequent power breakdowns and dehydration as citizens were fasting during the Islamic Holy Month of Ramadan. The emergency departments of all major hospitals dealt with the majority of patients presenting with varying degrees of heat illness.

Heat stroke is a life-threatening illness characterized by an elevated core body temperature above 40°C and central nervous system dysfunction that results in delirium, convulsions or coma (4). During heat waves, major risk factors for heat stroke include heat exposure, high ambient temperatures, solar radiation, urban heat island effect, poor constitution, extremes of age, isolation and poor access to air conditioning (5). It is also relatively common among

persons with chronic mental disorders or cardiopulmonary diseases and those receiving medications that interfere with salt and water balance, such as diuretics, anti-cholinergic agents, and tranquilizers that impair sweating (6). Heat stroke is a result of the failure of the body to regulate its temperature accordingly along with a severe acute-phase response that culminates in release of heat-shock proteins (7). This results in multi-organ damage caused by the cytotoxic effect of the heat compounded by the inflammatory and coagulation responses of the host.

Heat-related illness includes a variety of disorders; heat stroke, heat exhaustion, heat cramps and heat rashes. Based on pathophysiology, Yashuka et al. have introduced a grading system to assess severity of heat illness (8). Grade I includes mild cases with heat cramps or syncope. Grade III is the presence of any one of the following three conditions; brain dysfunction, liver/kidney dysfunction, and disseminated intravascular coagulation (DIC) based on clinical examination and laboratory data. Grade II includes patients not fulfilling Grades I and III criteria.

Early reduction of body core temperature is the key to manage heatstroke, although no single established optimal cooling method is available. Different treatment modalities, both invasive and non-invasive, based on the principles of evaporation, conduction and convection are used for rapid heat dissipation before irreversible organ damage occurs. Some of these techniques include specialized cooling bed units, cold water immersion, cold blankets, and cold packs over neck, groin and axilla, wetting the body along with continuous fanning and the use of the muscle relaxant dentrolene (9).

In the summer of 2015, Karachi was severely affected by a heat wave during which the peak air temperature recorded was 44.8°C (10). Heat Index is a commonly used parameter based on relative humidity and maximum air temperatures to gauge what the temperature feels like. A heat index of more than 51.66°C is very likely to cause heat stroke (11). In Karachi the heat index reached 66.1°C and 58.3°C on 20 June and 22 June 2015, resulting in a high patient influx to emergency departments and associated mortalities (10). This retrospective study is based on the clinical profiles, the outcome of patients in terms of survival and the role of effect modifiers on mortality among heatstroke patients who presented to the emergency room (ER) during 20–27 June 2015 at a tertiary care hospital in Karachi.

Methods

A retrospective study using non-random consecutive sampling was carried out at the emergency and haematology departments of Liaquat National Hospital, Karachi during 20–27 June 2015. Patients with heat illness other than heat stroke, brought dead to ER or having incomplete medical records were excluded as per study plan (Figure 1). All patients with heat stroke who reported to ER during the study period had their demographic data, clinical

presentation, medical and drug history assessed. Severity of disease was graded using Yashuka et al. grading system as discussed (8). Glasgow Coma Scale (GCS) was used to determine neurological status; a score of 15–12 was considered as mildly impaired and between 11–9 as moderately impaired. Coma was defined as a score of 8–3 (12). Mobility was assessed using Knaus Chronic Health status Score and stratified into four groups as follows: Class A) normal health status; Class B) moderate activity limitation; Class C) severe activity limitation due to chronic disease; and Class D) bedridden patient (13). Evaporative cooling is defined as spraying water over the patient and facilitating evaporation and convection with the use of fans (9). This technique was implemented from 26 June onwards. Outcome of the study was ER or in-hospital mortality versus those surviving to discharge. Effect modifiers between survivors and non-survivors were compared.

Statistical analysis

Data was analyzed by using Statistical Package for Social Sciences (SPSS) version 21. Mean and standard deviation were computed for quantitative variable and frequency and percentage were calculated for qualitative variables. Stratification was done with regards to qualitative variables to see the effect of these modifiers on study groups by using Chi Square test and Fisher's exact test. Differences in quantitative variables were compared by using Independent t-test. P value of ≤ 0.05 was considered as significant.

Ethical considerations

This study was conducted after approval from the Research and Ethics Committee of Liaquat National Hospital, Karachi, Pakistan.

Results

A total of 315 patients (172 [54.6%] males and 143 [45.4%] females) with heatstroke were included in the study to assess the clinical presentation and disease outcome. For the study period the maximum air temperature ranged from 37–44.8°C with highest attendance of 159 patients recorded on 22 June, 2015 (10). The relationship of hospital visits and patient outcome is shown in Figure 2 . The mean age of the study population was 58.87 ± 17.68 years (range: 1–95). Mean GCS score was 12.03 ± 4.22 (range: 3–15). Majority of patients (n=208, 66%) had normal mobility. Most common concurrent disease present in 176 (55.9%) patients was hypertension. Fever was the most frequent complaint seen in 250 (79.4%) patients. The mean body temperature documented on presentation was 37.9 ± 1.44°C (range:36.1–41.1) with high fevers of 39.4°C or above recorded in 69 patients of which 19 expired in ER. Central nervous system (CNS) disturbances were seen in 231 (73.3%) patients with 70 (22.2%) patients presenting in a comatose state (GCS Table 1.

Demographic features such as age groups and gender were almost similar between survivors and non-survivors. The mean age of survived patients was 58.55 ± 17.55 years while mean age was 59.94 ± 18.19 years for non-survivors. A significant association of survival status was found with fever (P = 0.045) and disease severity (P = Table 2.

Discussion

Heatstroke occurs in epidemic form during heat waves, and both hospital emergency department visits and intensive care unit (ICU) admissions increase sharply more so during first seasonal heat waves (14–16). Consecutive days of heat exposure, even among a heat-acclimated population can increase mortality risk (17,18); low- and middle-income countries are more vulnerable to these adverse effects (19). The lives of the poor in many hot countries are already compromised by routine summer heat. Extrapolating this to the global thermal environment projected in future decades gives a scenario where their situation will deteriorate and increasingly, other countries will begin to experience these oppressive climatic conditions.

Findings in our report indicate a mortality of 23% from heat stroke, while 33% was reported by Mohnasalven et al., although their sample size was limited to 15 patients (20). Current studies, now based on relative changes in all-cause mortality during heat stroke show an upward trend when compared to previous years (21). Non-work related heat illness is more common among the older population (22,23). Our data differ slightly as the mean age of heat stroke patients was close to 60 years with 18 patients aged less than 25 years. This difference can be attributed to the confounding effect of exertional heat stroke cases inadvertently included in the study.

Comparisons between males and females show a high but non-significant increase in mortality among females in this study, which concurs with other studies based on non-exertional heat stroke data (24). We found hypertension and not diabetes mellitus as the leading associated disease in this study, although the latter is known as a strong effect modifier for mortality among heat stroke patients due to impairment of the autonomic control and endothelial function in diabetic patients. (25–27). Contrary to the fact that drugs such as thiazide diuretics, vasoconstrictors and beta blockers affect the thermo-regulation by decreasing body’s ability to shunt large volumes of blood away from the centre to dissipate heat, no significant association was found between long-term drug use and mortality among our study population. Another common parameter that failed to leave its mark on mortality in this report was restricted mobility, although it was close to be significant at P value of 0.066. The above mentioned discrepant results hint at major differences in dynamics between high-income and low- and middle-income countries.

We found history of fever and disease severity at presentation as the only significant risk factors for death in this study. Patients with fever and severe disease manifestations are inclined to have low GCS score and a high risk of mortality, hence a poor outcome (28,29). Initially high mortality rates occurred in the ER in the first four days, since the public and healthcare providers were unprepared for the adverse climatic conditions. Patients were managed in ER using random cooling methods and irregular intravenous fluid administration. Three days later specific measures were implemented that included evaporative cooling combined with air conduction with installation of pedestal fans, maintaining room temperature at 22–24°C, rigorous hydration with intravenous fluids and designating four ICUs exclusively for managing these patients. These measures brought down the mortality rate from 24.35% to 15.9%, which was equivalent to a 35% reduction. The Evaporative conduction cooling technique was adapted since it is considered an effective cooling mechanism at high ambient temperatures, is well tolerated by elderly patients, and is more suitable for classic heat strokes in epidemic situations due to ease of application and access (9).

Despite climate change related risks of heatstroke, there is a temporal trend for a decline in mortality, which can be due to easy access to healthcare, change in age structure and resilience to warm climate over time (30). Ahmadabad in the state of Gujarat implemented its “Heat Action Plan” in 2013 and hence suffered fewer deaths than cities without heat plans during the May 2015 heat wave (31). We saw a high mortality during the one week period due to lack of a heat health action plan as well as a heat health warning system on a national level and a lack of preparedness on a local level.

A single centre study such as this may not be enough to depict an overall picture; nevertheless, our results have implications for the future. Further studies should consider the socioeconomic and infrastructural issues of heat-sensitive population groups in order to better manage heat-related illnesses in future.

Conclusion

This study of health data during the June 2015 heat wave in Karachi saw an upsurge in mortality and morbidity during the peak heat wave period, with a decline after introducing appropriate measures. Fever and disease severity were found to exert a significant impact on disease outcomes. Old age, comorbid conditions, medications and restricted mobility had no significant influence on mortality.

Limitations

This study has a number of limitations due to its retrospective nature; patterns of external or internal heat exposure were not documented and thus made it difficult to differentiate between

exertional and non-exertional heat stroke. Patients' socioeconomic status was not evaluated, which could have helped in understanding the demographics of heat-related illnesses. In addition, being a retrospective study the response to the cooling measures applied (assessed by fall in body temperature per minute) was not recorded. Like any observational study, our results may be subject to confounding bias.

Recommendations

To prevent possible rapid increases in mortality in future due to changing climatic conditions, it is recommended to develop a heat wave response plan that can be implemented in a timely manner. Additional prospective studies examining heat-related morbidity and quantifiable response to management are necessary for health risk assessments.

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Résultats pour les patients victimes d'un coup de chaleur orientés vers un hôpital tertiaire au Pakistan : étude rétrospective

Résumé

Contexte : Le changement climatique a accru la menace de survenue des coups de chaleur dans les régions auparavant tempérées.

Objectifs : La présente étude avait pour but d'évaluer les résultats pour les patients en termes de mortalité et le rôle des modificateurs d'effet chez les patients victimes d'un coup de chaleur se présentant dans un hôpital de soins tertiaires à Karachi en juin 2015.

Méthodes : Une étude d'observation rétrospective a été menée sur des patients victimes d'un

coup de chaleur du 20 au

27 juin 2015 aux services des urgences d'un hôpital privé à Karachi, au Pakistan. Les données démographiques des patients, la sévérité des troubles, leur présentation et les résultats ont été déterminés. Les données statistiques ont été présentées sous forme de nombres, de pourcentages et d'écart-type ± moyen.

Résultats : Au total, 315 patients se sont présentés aux services des urgences ; 76,6 % des patients ont survécu et 23 % sont décédés. Les patients étaient des hommes pour 55 % et 60 % des patients étaient tout à fait capables de bouger. L'hypertension était le trouble concomitant le plus fréquent. La fièvre documentée chez 79,4 % des patients et les troubles du système nerveux central chez 73,3 % d'entre eux étaient les caractéristiques les plus fréquentes. On a constaté que la fièvre et la gravité des troubles avaient un impact significatif sur l'issue de l'événement. Le taux de mortalité est passé de 24,35 % à 15,9 % à partir du 26 juin grâce à l'utilisation de la technique du refroidissement par évaporation combinée à la conduction de l'air et au maintien de la température ambiante à 22-24 °C.

Conclusions : Les mauvais résultats enregistrés pendant un coup de chaleur peuvent être minimisés par une planification préalable et une intervention en temps opportun dans les pays à revenu faible ou intermédiaire.

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