Heat-related illness—Clinical profile and predictors of outcome from a healthcare center in South India

George Abraham Ninan¹, Karthik Gunasekaran¹, Jonathan Arul Jeevan Jayakaran¹, Jacob Johnson¹, Abhilash KPP², Kishore Pichamuthu³, Ramya Iyadurai¹

¹Department of General Medicine Unit V, Christian Medical College, ²Department of Emergency Medicine, Christian Medical College, Vellore, Tamil Nadu, ³Division of Critical Care, Christian Medical College, Vellore, Tamil Nadu, India

ABSTRACT

Background: Heat-related illness is a common medical emergency. There is failure of thermoregulatory mechanisms of the body resulting in multiple organ dysfunction syndrome which if not identified and treated urgently can result in high mortality rate and permanent neurological damage. This study provides description of clinical profile patients presenting with heat-related illness and identifies clinical and laboratory variables resulting in poor outcome. Methods: This retrospective study was done identifying adult patients admitted with a diagnosis of heat-related illness from April to August 2019 in tertiary care center. Their clinical profile, laboratory investigations and outcome were extracted from medical records and variables associated with poor outcome were analyzed for statistical significance. Results: Mean age of the patients in the study was 61 years with mean heat index of the localities being 39.6-degree C. 66% of patients had multiple organ dysfunction with central nervous system dysfunction (77%) followed by respiratory distress syndrome (61%) as the most common organ derangement. Evaporative cooling measures were incorporated in management of all patients, followed by cold saline infusion in 60%. Higher J-ERATO score at admission was found to be a predictor for underlying multiple organ dysfunction syndrome (P value < 0.029). The mortality rate associated with heat-related illness in this study was 11.1%. Conclusions: Multiple organ dysfunction is seen in majority of the patients and calculation of simple admission J-ERATO score helps in predicting the same. Declining mortality rate observed in our study as compared to the earlier studies could be attributed to increased awareness, prompt diagnosis and initiation of rapid cooling measures.

Keywords: Air-conditioned heat stroke units, heat-related illness, J-ERATO score, outcome

Introduction

Heat-related illness is a common medical emergency with life threatening consequences. Thermoregulatory mechanisms of the body fail in maintaining homeostasis during heat waves of summer resulting in multiple organ dysfunction syndrome (MODS) with significant neurological deterioration.¹ Heat accumulation within the body is a combination of environmental exposure, increased metabolic requirements, and restricted or obtunded cooling mechanisms.² The clinical spectrum of heat-related illness varies from early signs of dehydration, which could present as lethargy and generalized weakness. This could progress to heat cramps, where the patient could experience painful involuntary contraction of muscles, which usually resolves in a few hours with hydration and stretching of the muscles. Heat exhaustion is a mild version of a heat stroke with minimal neurological deterioration.

Address for correspondence: Dr. Jonathan Arul Jeevan Jayakaran, Department of General Medicine Unit V, Christian Medical College, Vellore, Tamil Nadu, India. E-mail: jonathan.aji@gmail.com

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involvement, along with temperatures between 37° and 40°C. Aggressive cooling measures are imperative at this stage sans which could progress to heat stroke.[4]

Earliest used definition of heat stroke worldwide was devised by Bouchama,[4] wherein he defined heat stroke as core body temperature above 40°C, accompanied by hot dry skin along with central nervous system dysfunction, such as delirium, convulsions, or coma. The relevance of core temperature was challenged in the following years as the core temperatures of these patients would have already begun to decrease in response to pre-hospital treatment or transfer to hospital.[5,6] Innovative classification systems have been developed without reference to core body temperature and estimating the severity of heat-related illnesses based on the grade of organ dysfunction caused.[7] Classic heat-related illness or non-exertional heat-related illness affects elderly individuals with underlying medical co-morbidities that impair thermoregulation, avert removal from hot environment, or restrict attempted access to hydration or cooling.[8] These conditions include cardiovascular disease, neurologic or psychiatric disorders, obesity and physical disability among many others.[9] Pathophysiology of heat-related illness lies in dysregulation of thermoregulatory mechanism. As the body temperature rises, cutaneous vasodilation allows increased blood flow to the skin[10], causing relative reduction in intravascular volume, decrease in visceral perfusion resulting in organ failure.[9,11] In addition, heat stress releases inflammatory cytokines causing activation of leukocytes and endothelial cells leading to systemic inflammatory response syndrome.[12]

In India, following establishment of Indian Meteorological Department, recording deaths due to heat wave was initiated in 1979 and in the annual reports on “Disastrous Events,” 505 deaths were reported from all over India in 2001. In 2015 deaths from heat stroke were recorded as 2040, 5 times as compared to 2001.[11] Over the years, heatwaves have inclined to begin earlier and temperatures rise to 40–43°C in various parts of India.[14]

Most common complications arising from heat stroke include acute respiratory distress syndrome, renal failure, shock, disseminated intravascular coagulation (DIC), rhabdomyolysis, hepatic dysfunction, and cerebral oedema.[15] Several assessment tools have been developed for predicting clinical outcome in patients with heat-related illness. Hayashida et al.[16] developed J-ERATO score in 2018 and validated the scoring through multiple independent cohorts in Japan. J-ERATO score was defined as the sum of the six binary components (systolic blood pressure <100 mmHg, respiratory rate >22/min, body temperature >38°C, heart rate >100 beats per minute, age >65 years, and Glasgow coma scale <15), for a total score of 6. Multivariate analyses performed at validation of J-ERATO score reported it to be independent positive predictor for in-hospital mortality, hospital admission, intensive care unit admission. This allows high alertness and early initiation of rapid cooling measures to contain the mortality and morbidity of heat-related illness.

### Patients and Methods

#### Patients and setting

This retrospective study was conducted in tertiary care center in South India where in adult patients admitted with a diagnosis of heat-related illness during the summer months of April to July of 2019 were included. Patient search was initiated with assistance from medical records division and all consecutive in-patients who were admitted under Department of Medicine between April 1st 2019 and August 31st 2019 with a diagnosis of heat-related illness were identified and included in the study. Medical records of patients were reviewed and demographic details, comorbidities, symptomatology and duration illness prior to presentation, temperature at arrival, vitals, Glasgow coma scale, clinical examination findings, course of hospital stay, condition at discharge, outcome, radiological and blood investigations were recorded. The location of dwelling of patients were plotted on map and heat index was obtained through historical search from meteorological database.[17,18] Patients with proven central nervous system infection, sepsis with identifiable source and malaria were excluded.

#### Patient management and outcome parameters

All patients were managed with supportive therapy including fluid resuscitation, correction of dyselectrolytia, hemodynamic support, mechanical ventilation, renal replacement therapy as indicated. Dedicated air-conditioned heat stroke ward was used for sicker patients. Organ system dysfunction was quantified using SOFA score (sequential organ failure assessment score) with variables being entered using clinical and laboratory parameters available and a score of 2 or more was considered to have MODS. J-ERATO score was also calculated based on vitals at presentation as assessment of early risk predictor and severity of heat-related illness was graded into low risk (score 1–4) and high risk (score 5–6) based on the same. The outcome of interest was mortality, need for ventilation, need for intensive care unit, and duration of hospital duration. Using the presence of MODS as high mortality indicator, various initial parameters were compared for assistance in prediction of poor outcome.

#### Ethical approval and funding

This retrospective study protocol was approved by the Institutional Ethics Review Board (IRB NO: 12260), Christian Medical College, Vellore, India. In this study, data was collected from the hospital inpatient electronic medical records, the information collected was anonymized.

#### Statistical analysis

Data was entered into a Microsoft Excel worksheet and results obtained were subjected to statistical analysis. Descriptive statistics were employed for all the variables in the study. Categorical and continuous variables were compared for outcome using the Fisher’s exact test and student t-test, respectively. All continuous data were expressed as mean with standard deviation (SD) unless the data was not normally distributed. A P value of <0.05 was
considered statistically significant. Statistical analysis was done using Statistical Package for Social Sciences for Windows (SPSS Inc. Released 2007, version 16.0. Chicago).

**Results**

Data of 27 patients were included in analysis. 55% of the patients included in the study were females. Mean (SD) age of the patients included was 61 (13.5) years. The mean heat index of the localities were the patients were dwelling prior to presentation was 39.6°C, ranging from 37°C to 42°C. Baseline evaluation revealed that 48% of the patients had diabetes, 67% had hypertension, and 30% had underlying cardiovascular disease.

Medications which predispose patients to heat-related illness were reviewed and one third of them were found to be on beta blockers. Only 2 (7%) and 3 (11%) of the patients were on diuretics and antipsychotic medications, respectively. Baseline characteristics are described in Table 1.

The location of residence of the patients were plotted on geographical map as shown in Figure 1 which provides pictorial representation of distribution of cases and clustered cases indicates areas of higher case incidence. Contrary to the idea that dehydration in patients presenting with heat-related illness would result in hypernatremia and elevated lactate, 60% of the patients presented with hyponatremia with none having hypernatremia at presentation and only 25% had lactate elevation more than 2 mmol/L.

Patients with SOFA score >2 were considered to have MODS, which was the case with 66% of the admissions. Among the patients with organ dysfunction most common involvement was CNS dysfunction (77%), followed by respiratory distress syndrome (61%), acute kidney injury (50%), and hepatic dysfunction (22%) [Figure 2]. 16% of the patients with MODS required intensive care unit admission with ventilatory and vasopressor support and only one in three survived in spite of the same. Overall mortality of heat-related illness among in-patients was 11.1% and one among them had a SOFA score of 11 which was predictive of high risk of mortality. The treatment and outcome variables are described in Table 2.

Using statistical analysis, correlation of variables in predicting MODS and subsequently mortality was studied. Higher J-ERATO score at presentation was found to be an independent predictor for underlying MODS with significant \( P \) value of 0.029. However, none of the variables were found to predict mortality [Table 3].

**Discussion**

Heat-related illness encompasses a spectrum of illness which ranges from heat exhaustion to heat stroke. The aim of this retrospective study was to profile patients admitted with heat-related illness, identify risk factors which predisposes them to heat-related illness and identify predictors for MODS. This study was conducted in a tertiary care center in Vellore district of Tamil Nadu where heat waves are common in summer months and ambient temperatures recorded reach more than 40°C.

The overall mortality rate associated with heat-related illness in this study was 11.1%. Similar studies done by contemporaries in the same center had reported mortality rate of 50% in 2005\(^{[9]}\) and as high as 92.8% in 1998 [Figure 3]. These trends are welcome especially in the setting of climate change and global warming resulting in hotter summers. Reasons for this significant decrease in mortality could be attributed to early recognition due to increased awareness among healthcare workers, rapid cooling assisted by advancement in air conditioning facilities which

![Figure 1: Figure depicting distribution of cases as red triangles in district of Vellore](image-url)
have extended to include emergency department and dedicated heat-related illness wards in summer months.

Demographic details of the patients reveal that elderly (age more than 60 years) were most commonly affected and high proportion of them have underlying co-morbidities which have been implicated in non-exertional heat-related illness for decades. High prevalence of hypertension combined with anti-hypertensive medications such as beta blockers and diuretics further put them at risk for developing heat-related illness. Topographical distribution reveals clustering of cases within the urban sector of the city. This data could be biased as the healthcare center was in close proximity to the affected patients. However, being a referral center, it also received cases from other districts. However, spreading awareness among population within these neighborhoods would be a daunting yet rewarding venture in preventing heat-related illness.

Most patients presented within 2 days of illness with a core temperature at arrival of above 103°Fahrenheit. Assessing the vitals at presentation and looking for source of infection along with organ dysfunction is of prime importance but does not surpass the need for initiation of aggressive cooling methods. A simple binary pre-hospital score for risk assessment of patients with heat-related illness was validated in Japan[22] and is a composite of vitals at presentation along with age and core temperature. J-ERATO score was found to be an independent predictor of MODS (P value 0.029) in this study and using initial assessment with calculated of J-ERATO score, patients could be categorizing into those more susceptible for MODS; hence, identifying those needing prompt intensive care unit admission. A previous similar study done in same center had concluded that high levels of CPK (1000 IU/l), metabolic acidosis, and elevated liver enzymes were associated with MODS.[23] Electrolyte abnormality, in particular sodium, has also been studied as a predictor for mortality in heat-related illness. Study conducted by Haufaster et al.[24] concluded serum sodium abnormalities were frequently seen in patients with non-exertional heat-related illness; however, only hypernatremia was found to be an independent risk factor of death. Most of the patients in this series had presented with hyponatremia, which were similar to studies conducted by Lakhotia et al.[21] and Mohanaselvan et al.[22], and no predictive potential for mortality or development of organ dysfunction could be delineated statistically.

Among patients with MODS, neurological obtundation as depicted by GCS score of less than 15 was most common, followed by acute respiratory dysfunction. Higher intensive care admissions were seen in patient with MODS with only one in three surviving the same. Statistical analysis was not able to conclude with significance any predictor for mortality. However, this finding should be considered with caution in view of low mortality rates in this series. Assessment of severity using simple at admission J-ERATO score at primary care level and initiation of cooling measures and triage of patients with MODS to higher centers by primary care physician can improve morbidity and mortality.

Being a retrospective study, there are limitations. Variation in diagnostic investigations and therapeutic practice could have

Table 2: Treatment and outcome variables of patients with heat-related illness (n=27)

| Variable                        | Values       |
|---------------------------------|--------------|
| Evaporative cooling method      | 27 (100)     |
| Cold saline infusion            | 16 (59.3)    |
| Presence of MODS                | 18 (66.7)    |
| Use of vasopressors             | 3 (11.1)     |
| Need for ICU care               | 2 (7.4)      |
| Need for mechanical ventilation | 3 (11.1)     |
| Duration of hospital stay, mean±SD, days | 7.44±3.21 |
| Mortality                       | 3 (11.1)     |

MODS=Multi organ dysfunction syndrome, ICU=Intensive care unit

Table 3: Comparing patients with heat-related illness with and without multi-organ dysfunction

| Characteristics                          | MODS present (n=18) | MODS absent (n=9) | P    |
|-----------------------------------------|---------------------|-------------------|------|
| Age, mean±SD, years                     | 64.5±11             | 56±16.9           | 0.12 |
| Duration of illness, mean±SD, days      | 2.3±1.1             | 2.3±1.3           | 0.71 |
| Temperature at presentation, mean±SD, degree Fahrenheit | 103.6±1.9 | 103.2±1.4 | 0.65 |
| J-ERATO score                           | 3.7±0.9             | 2.7±0.8           | 0.01*|
| Leukocytes, mean±SD, cmm                | 11,455±4762         | 11,711±4880       | 0.89 |
| Sodium, mean±SD, m mol/l                | 131±10.1            | 127±10.8          | 0.37 |
| Metabolic acidosis (HCO3<18 mEq/L)      | 9 (50.0)            | 2 (22.2)          | 0.17 |
| CPK >1000 U/L                           | 7 (38.9)            | 3 (33.3)          | 0.78 |
| Mortality                               | 2 (11.1)            | 1 (11.1)          | 1.00 |

MODS=Multi organ dysfunction syndrome, CPK=creatin phosphokinase, *significant value
influenced the outcome. The small number of patients included and low mortality rate limited statistical analysis with multiple logistic regressions. These limitations could be overcome with a prospective study with sufficiently large sample size.

Identification of similar clinical syndrome complex along with supportive risk factor evaluation and laboratory investigations could help primary physician in earlier diagnosis of heat-related illness. Application of J-ERATO score for prognostication of multiple organ dysfunction syndrome could assist decision making in early referral or intensive care admission after prompt cooling measures have been initiated.

**Conclusion**

MODS is seen in majority of patients with heat-related illness and calculation of simple at admission J-ERATO score helps in predicting the same, warranting intensive care unit admission and close monitoring. The overall mortality rate associated with heat-related illness in this study was 11.1% which has significantly declined over last few decades. This could be attributed to increased awareness, prompt diagnosis and rapid cooling measures coupled with air-conditioned emergency department and dedicated heat-related illness wards during heat waves.

**Research quality and ethics statement**

The authors of this manuscript declare that this scientific work complies with reporting quality, formatting and reproducibility guidelines set forth by the EQUATOR Network. The authors also attest that this clinical investigation was determined to require Institutional Review Board/Ethics Committee review, and the corresponding protocol/approval number is IRB Min. No. 12260. We also certify that we have not plagiarized the contents in this submission and have done a Plagiarism Check.

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**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Dematte JE. Near-fatal heat stroke during the 1995 heat wave in Chicago. Ann Intern Med. 1998;129:173.
2. Gauer R, Meyers BK. Heat-related illnesses. Am Fam Physician 2019;99:482-9.
3. Ho S-L. Managing heat exhaustion in primary care. The Pharmaceutical Journal 2014;07;293(7817).
4. Bouchama A, Knochel JP. Heat stroke. N Engl J Med 2002;346:1978-88.
5. Yamamoto T, Todani M, Oda Y, Kaneko T, Kaneda K, Fujita M, **et al**. Predictive factors for hospitalization of patients with heat illness in Yamaguchi, Japan. Int J Environ Res Public Health 2015;12;11770-80.
6. Shapiro Y, Seidman DS. Field and clinical observations of exertional heat stroke patients. Med Sci Sports Exerc 1990;22:6-14.
7. Yamamoto T, Fujita M, Oda Y, Todani M, Hifumi T, Kondo Y, **et al**. Evaluation of a novel classification of heat-related illnesses: A multicentre observational study (Heat Stroke STUDY 2012). Int J Environ Res Public Health 2018;15:1962.
8. Klenk J, Becker C, Rapp K. Heat-related mortality in residents of nursing homes. Age Ageing 2010;39:245-52.
9. Gaudio FG, Grissom CK. Cooling methods in heat stroke. J Emerg Med 2016;50:607-16.
10. Miyake Y. Pathophysiology of heat illness: Thermoregulation, risk factors, and indicators of aggravation. Japan Med Assoc J 2013;56:167-73.
11. Deschamps A, Levy RD, Cosio MG, Marllis EB, Magder S. Effect of saline infusion on body temperature and endurance during heavy exercise. J Appl Physiol 1989;66:2799-804.
12. Huisse M-G, Pease S, Hurtado-Nedelec M, Arnaud B, Malaquin C, Wolff M, **et al**. Leukocyte activation: The link between inflammation and coagulation during heatstroke. A study of patients during the 2003 heat wave in Paris. Crit Care Med 2008;36:2288-95.
13. State/UT-wise Casualty Recorded due to Heat Wave from 2015 to 2018 (From: Ministry of Housing & Urban Affairs) | Open Government Data (OGD) Platform India [Internet]. [cited 2020 Jun 11]. Available from: https://data.gov.in/resources/state‑ut‑wise‑casualty‑recorded‑due‑heat‑wave‑2015‑2018‑ministry‑housing‑urban‑affairs.
14. Jain Y, Srivatsan R, Kollannur A, Zachariah A. Heatstroke: Causes, consequences and clinical guidelines. Natl Med J India 2018;31:224-7.
15. Tek D, Olsheker JS. Heat illness. Emerg Med Clin North Am 1992;10:299-310.
16. Hayashida K, Kondo Y, Hifumi T, Shimazaki J, Oda Y, Shiraishi S, **et al**. A novel early risk assessment tool for detecting clinical outcomes in patients with heat-related illness (J-ERATO score): Development and validation in independent cohorts in Japan. PLoS One 2018;13:e0197032.
17. Vellore Historical Weather [Internet]. WorldWeatherOnline.com. [cited 2020 Apr 11]. Available from: https://www.worldweatheronline.com/lang/en-in/vellore-weather/tamil-nadu/in.aspx.
18. Vellore, Tamil Nadu, India Monthly Weather | AccuWeather [Internet]. [cited 2020 Apr 11]. Available from: https://www.accuweather.com/en/in/vellore/190795/february-weather/190795.
19. Varghese GM. Predictors of multi-organ dysfunction in heatstroke. Emerg Med J 2005;22:185-7.
20. Hausfater P, Mégarbane B, Fabricatore L, Dautherville S, Patzak A, Andronikof M, **et al**. Serum sodium abnormalities during nonexertional heatstroke: Incidence and prognostic
21. Lakhotia R, Longani S, Bogra J, Aggarwal A. Profile of Patients Admitted to ICU with Heat Related Illnesses - A Clinical Study. International Journal of Contemporary Medical Research. 2017 Jul;4(7):15302.

22. Mohanaselvan A, Bhaskar E. Mortality from non-exertional heat stroke still high in India. Int J Occup Environ Med 2014;5:222-4.