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# Heat Stroke in Karachi, Pakistan - Metabolic Derangements and Multiorgan Dysfunction

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## 1. Abstract:

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***Background***: Heat stroke is a life threatening illness with significant morbidity and mortality which is secondary to multi organ dysfunction. Present study described the analyses of laboratory parameters such as electrolytes ($Na^+$, $K^+$, $HCO_3^-$), renal and hepatic function tests and Cardiac Troponin I in heat stroke patients. ***Material and Methods***: It was a retrospective observational study conducted in the Department of Biochemistry Lab services and Chemical Pathology, Liaquat National Hospital and Medical College Karachi from 21 June 2015 to 26 June 2015, a non probability sampling with a sample size of 187. Both males as well as females who fulfilled the diagnostic criteria of non exertional heat stroke and were admitted in the hospital were included in our study. Blood was collected and creatinine, sodium ($Na^+$), potassium ($K^+$), chloride ($Cl^-$), bicarbonate ($HCO_3^-$), Alanine Aminotransferase (ALT) and Troponin I levels were analyzed by standard methods. ***Results***: Out of the 187 patients diagnosed with heat stroke, hyponatraemia was seen in 63%, hypokalaemia was observed in 39%, 41% had low serum $HCO_3^-$ levels, Elevated Trop I levels were observed in 33%, impaired renal and hepatic function as measured by their creatinine and ALT levels, was present in 48% and 24% patients, respectively. ***Conclusion***: Heat stroke could lead to multi organ damage, with necrosis and haemorrhage occurring in the heart, liver, lungs, brain, kidneys and gut. The population should be educated as to the causes and prevention of heat stroke. Health workers should be aware of this potentially life threatening illness and rigorous treatment is necessary to prevent the morbidity and mortality associated with it.
**Key words:** Heat stroke, non-exertional heat stroke, extertional
**Short title:** Heat stroke and multiorgan dysfunction

## 2. Introduction:

Heat stroke is a life threatening illness which is characterized by an elevated body temperature more than 40°C and central nervous system dysfunction resulting in delirium, convulsions and coma [1]. It can also be defined as a form of hyperthermia associated with systemic inflammatory response leading to a syndrome of multi organ dysfunction in which encephalopathy predominates [1]. Heat stroke could lead to multi organ damage, with necrosis and haemorrhage occurring in the heart, liver, lungs, brain, kidneys and gut [2]. There are two forms of heat stroke, classical or non exertional heat stroke (NEHS) and exertional heat stroke (EHS) [3]. Exertional heat stroke occurs in healthy young people who are exercising in hot and humid climates (Table 1). Classical or NEHS occurs during extreme heat waves, most commonly affecting the elderly and young children [2]. A core body temperature above 42°C can lead to cellular destruction in 45 minutes to eight hours. At higher temperatures, cellular destruction is more rapid and intense [4] (Table 2).

In the summer of 2015, the heat index (a measure of temperature and humidity), broke all world records in Iran. A total of 40,000 cases of heat stroke were reported in Pakistan. In Andhra Pradesh in India, 1400 people lost their lives in 1 month. There are predictions that conditions will worsen by the end of the century, due to rise in temperatures along with an increasing shortage of water [5]. Inadequate hydration is also a key factor as people drink less water or drink fructose containing sugary beverages which will exacerbate the renal injury and hence the electrolyte imbalance [5]. In July 2012, 32 persons died from excessive heat exposure in four states of the US. Their median age was 65 years. Most of them died at home due to lack of air conditioning [6].

The objective of the present study is evaluate the laboratory parameters in heat stroke patients such as electrolytes ($Na^+$, $K^+$, $HCO_3^-$), renal and hepatic function tests and Cardiac Troponin I

## 3. Materials and Methods:

This was a retrospective observational study conducted in the Department of Biochemistry Lab services and Chemical Pathology, Liaquat National Hospital and Medical College Karachi from 21 June 2015 to 26 June 2015. The sampling technique was non probability sampling with a sample size of 187. Both males as well as females who fulfilled the diagnostic criteria of non exertional heat stroke and were admitted in the hospital were included in our study. However, those patients who were pronounced dead on arrival or died due to heat stroke within a few hours were excluded. Blood samples were collected in lithium heparin tubes. Their creatinine, sodium ($Na^+$), potassium ($K^+$), chloride ($Cl^-$), bicarbonate ($HCO_3^-$), Alanine Aminotransferase (ALT) and Troponin I levels were analyzed. Creatinine and Alanine Aminotransferase (ALT) were quantified on Cobas c501 by spectrophotometry with a reference range of 0.5-1.5 mg/dl for creatinine and <31U/l in females and <41 U/l in males for ALT. $Na^+$, $K^+$, $HCO_3^-$ were assayed on Nova electrolyte analyzer using ion selective electrodes (ISE). The reference ranges for the electrolytes were, 136-145 mmol/l, 3.5-5.3 mmol/l and 22-34 mmol/l for $Na^+$, $K^+$, and $HCO_3^-$ respectively. Trop I was assayed on Cobas e411 by electrochemiluminescence (ECL) with a cut-off of <0.30 ng/ml.

## 4. Results:

Out of the 187 patients diagnosed with heat stroke, hyponatraemia was seen in 63% (Fig 1), hypokalaemia was observed in 39% (Fig 2), 41% had low serum $HCO_3^-$ levels (Fig 3). Elevated Trop I levels were observed in 33% (Fig 4), impaired renal and hepatic function as measured by their creatinine and ALT levels, was present in 48% (Fig 5) and 24%

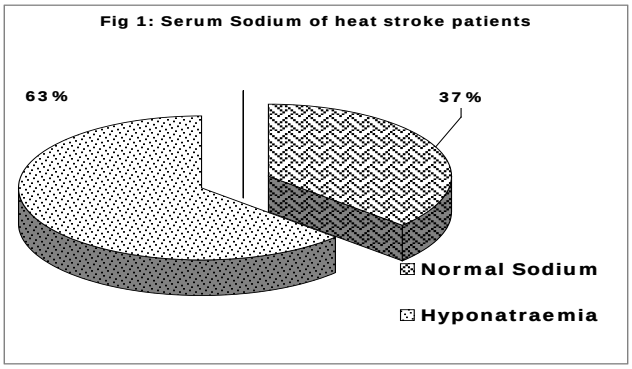
respectively (Fig 6). The mean sodium levels in the normal subjects were 137 mmol/L whereas the hyponatraemic patients had mean sodium levels of 126 mmol/L. The mean potassium levels in the normal range were 3.9 mmol/L and 2.9 mmol/L in the hypokalemic patients. Mean serum bicarbonate was 25 mmol/L and 19 mmol/L in the normal and low bicarbonate subjects respectively. The mean level of Trop I in the normal patients was 0.14, whereas it was 5.14 in the patients showing elevated Trop I levels. For the renal function tests, the mean creatinine was 0.9 mg/dl and 2.3 mg/dl in the patients with normal renal function and impaired renal function respectively. For the hepatic function tests, the mean ALT levels were 19 U/L and 160 U/L respectively.

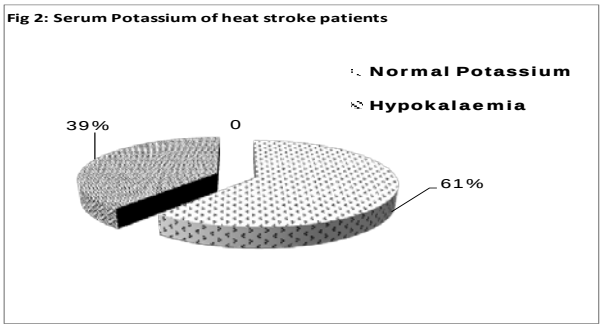
**Table 1: Presentation of 'classical (non-exertional)' and 'exertional' heat stroke [2]**

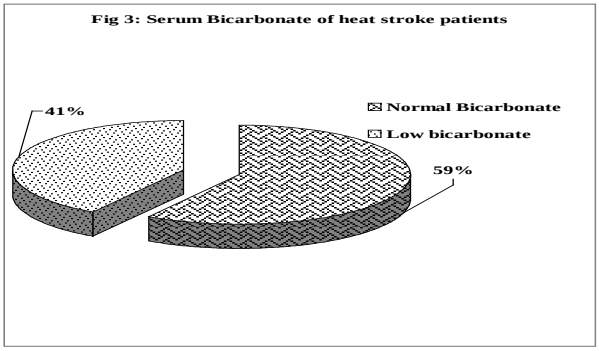
| | *Classical (NEHS)* | *Exertional (EHS)* |
|---|---|---|
| **Age group** | Infants, elderly | 15-65 yrs |
| **Health status** | Acute/chronic illness | Usually healthy |
| **Activity** | Sedentary | Usually highly active e.g. athletes, army personnel |
| **Drug use** | Diuretics, Antiparkinsonians, Anticholinergics, Tricyclic antidepressants | |

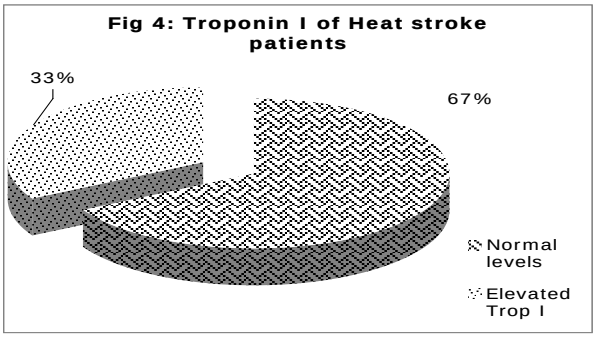
**Table 2: Predisposing factors for heat stroke [7]**

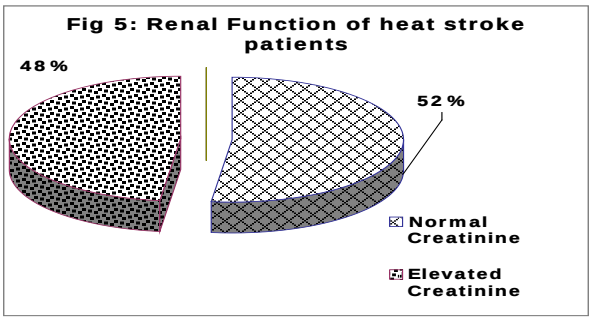
| Factors |
|---|
| ▸ Ambient temperature ≥ 35° C (e.g. during heat wave) |
| ▸ Humidity > 75% |
| ▸ Extremes of age |
| ▸ Obesity |
| ▸ Alcohol intake |
| ▸ Febrile illness |
| ▸ Sleep deprivation |
| ▸ Non-acclimatization |
| ▸ Inappropriate clothing - which prevents dissipation of heat |
| ▸ Drugs: Diuretics, phenothiazines, antiparkinsonians, tricyclic antidepressants |



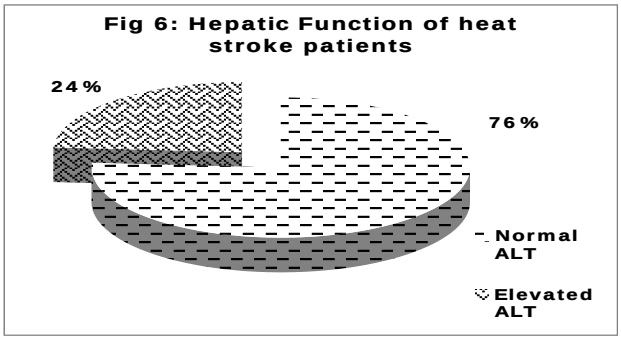




## 5. Discussion:

Present study described the alteration electrolytes and body function tests in heat stroke patients. Hyponatraemia, hypokalaemia, low serum $HCO_3^-$, Elevated Trop I, impaired renal and hepatic function were observed in most of the patients. Previously, a study from India reported hyponatraemia in 33%, hypokalaemia in 40% and acute renal insufficiency in 47% of patients [8]. These values of hypokalemia and acute kidney

disease were similar to our studies. Hyponatremia was present in a larger group of people that is 63% in our study compared to 33% reported earlier [8]. This could be due to pure water intake by our patients leading to hyponatremia.




Another study reported heat stroke patients of Chicago and found multi organ dysfunction and neurological impairment in 100% and moderate to severe renal insufficiency in 53% of patients [9].The values reported in that study are in agreement with the results noted in our study.

Some research studies also included electrocardiographic changes in patients with heat stroke [10]. It was noted that all components of the ECG could be affected, including rhythm disturbances, conduction defects, prolongation of the Q-T interval and ST segment abnormalities [10]. In such studies, cardiac changes were found in 21% of patients [10]. When these changes were compared with the elevated Troponin I levels found in our study, we observed an elevated Trop I of 33% which is consistent with clinical outcome, however, slightly more than what was noted in the ECG changes [2, 10]

Earlier, metabolic and respiratory alterations in heat stroke from a total of 21 patients were studied [11]. The researchers found metabolic acidosis in 15 patients with bicarbonate of 14 ± 1 mEq/L which is in agreements to our findings. A similar study was performed by Varghese et al [12], who demonstrated elevated levels of serum creatinine in 64.3% of the patients and elevated liver enzymes in 61%. However, these reported values were much higher than our study. Furthermore, epidemics of CKD (Chronic Kidney Disease) consistent with HSN (heat stress nephropathy) are now occurring throughout the world. HSN may represent one of the first epidemics due to global warming [5]. A case study by Wijerathne et al [13] showed the presence of exertional heat stroke in a soldier with early signs of renal failure, liver failure and rhabdomyolysis with elevated creatinine and ALT levels. This is consistent with our findings as been observed in many patients.

## 6. Conclusion:

Heat stroke is a life threatening illness with significant morbidity and mortality which is secondary to multi organ dysfunction. The population should be educated as to the causes and prevention of heat stroke. Health workers should be aware of this potentially life threatening illness and rigorous treatment is necessary to prevent the morbidity and mortality associated with it.

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