LESSONS FROM HISTORY

Clinical Description of Heat Illness in Children, Melbourne, Australia—A Commentary

Michael Yaron, MD; Susan Niermeyer, MD

From the Division of Emergency Medicine (Dr Yaron) and the Department of Pediatrics, Section of Neonatology (Dr Niermeyer), University of Colorado Health Sciences Center, Denver, CO.

Concerns about the health effects of global warming and the adequacy of the public health response to environmental crises heightened recently when record-high temperatures across France in the summer of 2003 resulted in the death of nearly 15 000 persons, many of them elderly. The accompanying article by Danks and associates highlights another group vulnerable to heat illness, that of young children. The authors describe their experience treating heat illness in young children during a 3- to 7-day heat wave in the region around Melbourne, Australia, in 1959. This heat wave was distinguished as the most intense on record for the previous 50 years. The temperatures were sustained at 35°C to 48°C (95°F–109°F) during the day and 24° to 32°C (75°F–90°F) at night. Of 47 ill children, 6 were pronounced dead on arrival, and 6 more died from heat-related causes after admission.

This report presents one of the first and most detailed clinical descriptions of heat illness in children. As is true of many conditions encountered in wilderness and environmental medicine, the early scientific interest in heat illness centered primarily on adults in the military. [A review of the paper by Buskirk, “Work performance after dehydration: effects of physical conditioning and heat acclimatization,” previously appeared in *Lessons from History* (*Wilderness Environ Med.* 2000;11:202–203)]. Initial epidemiological study of deaths among civilian populations during environmental heat waves identified the elderly, the poor, and those with pre-existing disease as being at special risk. The authors of the current paper turned a potentially overwhelming influx of critically ill children into a careful analysis that demonstrated the vulnerability to heat illness in the other extreme of the age spectrum. It deserves note that 2 physicians in training (a registrar and a house physician) and a social worker at the children’s hospital in Melbourne formed an unusual and effective team of investigators to perform this study. They present a vivid and useful clinical description based on the classical elements of the medical his-

tory (past medical history, history of present illness, review of systems, family and social history) and physical examination, despite their limited access to laboratory and diagnostic resources.

All children in the series reported were 6 years of age or younger and only 2 children were older than 4 years. The most striking feature of the case series is the importance of specific medical and social risk factors among the children. The authors report an analysis of preexisting medical conditions, developmental state, acute illnesses, conditions of the home environment, and skills of the mother. The most important predisposing factor for illness or fatal outcome, in 31 of 47 children, was severe chronic disease, most often developmental delay, associated with the history of feeding difficulty. “Maternal ability” and housing conditions were assessed by the social worker, who conducted home visits in 38 cases. Among those patients who were dead on arrival, poor maternal ability (failure to recognize the need for additional fluid or fluids other than cow’s milk) and poor housing (excessive internal temperatures) were notable. The authors did cite delayed or misleading advice from physicians and distance from home to hospital as playing a role in several fatal cases because of the rapidity of the final deterioration.

The descriptions of the sequence of clinical signs and the sudden changes that occur with heat illness in young children remain accurate and useful today. “On arrival at hospital. . . the outstanding features were dehydration, poor peripheral circulation, and impairment of consciousness. . . Rapid deep respiration, without acidotic breath or ketonuria, was frequent, and irregular respirations occurred in the most ill.” The authors make the important point that dehydration, rather than hyperpyrexia, was more closely related to severe disturbance of consciousness and to subsequent seizures. They also emphasize the prodromal phases as variable in duration but leading inevitably to decompensation, at which point intervention may be too late. “The symptoms preceding

this clinical pattern were irritability and refusal to take fluids for a period of from several hours up to a day or two, then listlessness, followed by a rapid or even sudden deterioration with loss of consciousness. . . In some, death resulted within half an hour of this sudden worsening."

The constellation of thermoregulatory events in response to heat stress is manifested by both autonomic and behavioral processes. These processes modify the rates of heat production and heat loss via sweating, peripheral vasodilation, volume replacement, and seeking cooler ambient temperatures. Neonates and infants lack optimal thermoregulatory control. Their greater body surface-mass ratio allows for a greater heat transfer between the environment and their bodies. Sweating capacity is considerably lower in children than in adults, which reduces the ability of children to dissipate heat by evaporation. Furthermore, children do not instinctively replace their fluid losses or limit their exercise in extreme heat.

Danks and colleagues first called attention to a group of young children who were particularly vulnerable because of preexisting conditions or limited social or environmental circumstances. The pattern of particular vulnerability of the very young and the elderly has been shown repeatedly. Recent national statistics for the United States show a relative increased risk of heat illness among children aged 0 to 4 years, with a subsequent fall and then gradual rise toward the highest risk in the seventh and eighth decades of life.¹ A similar bimodal distribution of age ranges for lethal heat injuries is reported from Japan, where 50% of heat-related deaths from 1968 through 1994 occurred in children 4 years and younger and in the elderly 70 years and older.² Both the very young and the elderly may be unable to invoke protective behavioral responses for a number of reasons. These are the individuals who are unable to move to a cooler environment, take off their own clothing, or increase their fluid intake. Danks and colleagues noted that breastfeeding may have protected the smallest infants, as the infants could better regulate their own intake according to thirst and they received a lower renal solute load from breast milk, as compared with cow's milk. In children, coexisting illnesses such as cystic fibrosis may exacerbate the electrolyte losses with sweating. Medications in adults often cause alterations in sweating and vasoreactivity and may also alter judgment profoundly, as in the case of alcohol.

Danks' paper highlights the protective role that parents play in supporting the youngest and most helpless of our species. Despite the several thermoregulatory physiologic disadvantages of young children, their observed mortality continues to be less than the elderly because of this protective parental role. In the intervening years after Danks' report, social change has introduced new risk factors for children. Increased automobile travel involving young children and increased participation in competitive sports have introduced new behavioral risk factors for otherwise healthy children. Infants and children left unattended in motor vehicles are at risk for heat stroke and death because intravehicular temperatures rise rapidly in the sun.³ Young children and adolescents participating in competitive team sports do not adapt to extreme heat as effectively as adults.⁴ Education of physicians and adult caregivers regarding the importance of appropriate fluid administration, early recognition of dehydration (or fluid refusal), and alterations in mental status are needed to prevent unnecessary mortality.

Recent scientific assessments indicate that as the global temperatures continue to warm due to climate change, the number and intensity of extreme heat events might increase.⁵ Families, health care professionals, and communities at risk need advanced planning for management during a heat wave. Circumstances of risk, through both voluntary and involuntary exposure to heat, are numerous and variable. One constant, however, is the vulnerability of the elderly and the very young.

References

1. Adcock MP, Bines WH, Smith FW. Heat-related illnesses, deaths, and risk factors—Cincinnati and Dayton, Ohio, 1999, and United States, 1979–1997. *MMWR*. 2000;49:470–473.
2. Nakai S, Itoh T, Morimoto T. Deaths from heat-stroke in Japan: 1968–1994. *Int J Biometeorol*. 1999;43:124–127.
3. Krous HF, Nadeau JM, Fukumoto RI, Blackburn BD, Byard RW. Environmental hyperthermic infant and early childhood death: circumstances, pathologic changes, and manner of death. *Am J Forensic Med Pathol*. 2001;22:374–382.
4. Committee on Sports Medicine and Fitness (American Academy of Pediatrics). Climatic heat stress and the exercising child and adolescent. *Pediatrics*. 2000;106:158–159.
5. World Meteorological Organization. Extreme weather events might increase. WMO-No. 695. Available at: <http://www.wmo.ch>. Accessed July 2, 2003.