

Heat-Related Deaths

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Risk factors and criteria for classifying deaths as heat related are discussed with emphasis on investigation of the circumstances.

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There has been an increased awareness of heat-related illness and death in the popular press, as well as the medical literature, as a result of several heat waves in the Eastern and Midwestern United States during the 1990s and the recent death of a professional athlete from exertional heatstroke.

CASES OF HEAT-RELATED DEATHS

The following are circumstances of 7 deaths in hot environments:

Case 1: A 38-year-old male went out to his unshaded yard to stain a wooden swing set and playhouse at 9:30–10:00 AM. He was noticed lying on his back by the playhouse with 1 knee up at 11:15 or 11:30 AM by a neighbor. He was found dead in full rigor with bare chest and skin slippage over anterior chest at 2:30 PM in the same position.

Case 2: A 43-year-old male began weaving while riding his bicycle in a race, then fell onto the roadway and began having seizures at 12:17 PM.

Case 3: A 61-year-old male was found unresponsive and slumped over the console of his van at 2:26 PM “as if he was attempting

to transfer himself from the driver’s seat to the back of the van into his wheelchair.” The van was in the covered parking garage where he was to see his urologist regarding a fever of 102°F and a probable urinary tract infection. It was estimated that the maximum time he had been there was 1–1½ hours. Both front windows were wide open. He reportedly usually drove with the air conditioner on, but the position of the air conditioner switch was not noted.

Case 4: A 53-year-old male was seen baling hay at 11:00 AM. He was found unresponsive in either the hay field or a goat pen at approximately noon.

Case 5: A 17-year-old male was found dead, lying on his back on the back seat of a gray car at 8:10 PM in a parking lot (presumably unshaded) on the south side of an apartment building. A friend had left him there, passed out and snoring, at 9 AM. The friend reported that he had “cracked” the windows.

Case 6: A 56-year-old male complained that he “felt bad” with some mild chest pain to a friend at 4:15 PM while playing golf and went to sit in his air-conditioned car. He was found slumped over the steering wheel with

Table 1. Seven Cases of Heat-Related Death

Case	State	Month	Body Temperature	Outdoor Temperature (nearest weather station or locally reported)	Sky	Relative Humidity (nearest weather station or locally reported)	Heat Index (with full sun)	Meds
1 38 M	MD	late May	Police reported “The body was hot from lying in sun.”	91°F maximum for day 10 AM—84°F 1 PM—88°F	Clear Few clouds	78% maximum for day 10 AM—33% 1 PM—28%	85 (100)°F 90 (105)°F	None
2 43 M	MD	late July	108°F core on arrival to hospital	93°F maximum for day 10 AM—90°F 1 PM—88°F	Hazy	89% maximum for day 10 AM—66% 1 PM—75%	103 (118)°F 103 (118)°F	None
3 61 M	TX	late July	106°F core on arrival to hospital	102°F maximum for day Noon—95°F 2 PM—100°F	Clear	72% maximum for day Noon—41% 2 PM—32%	101°F 105°F	Unknown
4 53 M	GA	late July	106.4°F core on arrival to hospital	96°F maximum for day 10 AM—88°F	Clear	85% maximum for day 10 AM—66%	98 (118)°F	Unknown
5 17 M	KY	late June	Not done	92°F maximum for day 10 AM—85°F	Broken clouds	85% maximum for day 10 AM—75%	95 (110)°F	None
6 56 M	TX	late June	—EMT reported “pt. was cold to touch” —100.4°F core on ar- rival to a distant morgue 3¼ hours af- ter he was found	93°F maximum for day 4 PM—93°F	Broken clouds	91% maximum for day 3 PM—50%	100 (115)°F	Unknown
7 68 F	ME	mid June	—105.3 °F core on ar- rival to hospital —107 °F core 2¼ hours later	91 °F maximum for day 59 °F minimum for day	Unknown	53% minimum for day 90% maximum for day	Range of 98-122°F using maximum temperature	Perphenazine Desipramine Steroids

Table 2. Seven Cases of Heat-Related Death

Case	PMH	Clinical Course	Autopsy	BMI	Toxicology	Misc.	COD	Contributing Conditions
1 38 M	None	Dead at scene	—Single, small, peripheral pulmonary infarct, left lower lobe —Dilated, flabby heart (unremarkable histology) —Mild decomposition	28	Negative drugs and alcohol	Vitreous chemistries consistent with dehydration + superimposed decomposition	Heatstroke	Dehydration
2 43 M	None	—Seizures, DIC, rhabdomyolysis, renal failure —Died 2 days later	—Fractures of left clavicle and left ribs 2 & 3 —Left hemothorax – 1 L —Cardiomegaly (510 gm/mild for height) with LVH —Focal subendocardial hemorrhage —Cerebral edema —Pulmonary edema	26	—Antemortem blood; negative alcohol —Postmortem blood: negative drug screen		Heatstroke + blunt chest injuries	None
3 61 M	—C6/7 quadriplegia (remote) —Acute UTI—102°F fever —Chronic UTI	DOA	—Cardiomegaly (630 gm) with LVH —Mild-moderate focal CAD —Acute & chronic left pyelonephritis + abscess	30	Quinine or quinidine found on drug and alcohol screen	—Vitreous chemistries unremarkable —No cultures done	?Heatstroke vs. sepsis due to acute left pyelonephritis with abscess	—Hypertensive and ASCVD
4 53 M	Unknown	DOA “scalded skin appearance” on the forearms, legs, chest and chin	—Cardiomegaly (590 gm) —3-vessel CAD —Old posterior MI	42	Not done		Heatstroke	—ASCVD—severe —Morbid obesity
5 17 M	None	Dead at scene	—Pulmonary edema —Early decomposition	21	Blood alcohol—0.19%; drug screen negative		Heatstroke	—Acute alcohol intoxication

Table 2. Continued

Case	PMH	Clinical Course	Autopsy	BMI	Toxicology	Misc.	COD	Contributing Conditions
6 56 M	Cardiac history, not otherwise specified	Dead at scene	—Cardiomegaly (610) with dilated heart —1-vessel CAD —Small apical myo- cardial scar —Pedal edema —Fatty liver	36	Negative blood alcohol; no drug screen done		?Heatstroke vs. ASCVD	—Obesity
7 68 F	—Schizophrenia —Paraplegia —Indwelling uri- nary catheter —Recurrent UTI —Ulcerative co- litis	—Lethargy, hypox- emia, wheezing, tachypnea, tachycar- dia, diaphoresis —Hyperglycemia of 757 gm/dl —Neg. urine ketones —WBC —20K with left shift —Chest x-ray neg. —Mental status de- clined with rising temperature —Died 3½ hours later	—Focal acute cystitis —No acute pyelone- phritis —Laryngitis, probably viral —No microscopic evi- dence of meningitis —Moderate pulmonary edema —Cardiomegaly (520 gm)	26	Not done	—Blood cultures × 2 negative —CSF culture negative ex- cept for diph- theroid con- taminant	Heatstroke	—Psychotropic medications —Focal acute cystitis —?Viral laryngi- tis —Hyperglycemia with dehydra- tion

BMI—Body Mass Index in kg/m².

the motor running and the air conditioner on at 4:48 PM.

Case 7: A 68-year-old female was transferred to a hospital at 1:12 PM from a boarding home without air conditioning after several days of cough and low-grade fever.

Environmental conditions, past medical history, clinical course, autopsy findings, cause of death and contributing conditions of these 7 cases are listed in Tables 1 and 2.

DISCUSSION

Heat-related illness is a spectrum of progressively more severe illness, including heatstroke (hyperthermia), which is the most extreme form with a high mortality rate.

Heat stroke is typically classified as either exertional (due to exercise or heavy labor) or classic, due to the inability to dissipate heat in a hot and often humid environment and frequently related to one or more underlying risk factors. Risk factors include:

- Old age
- Children <5 years
- Social circumstances (eg, living alone, urban poor)
- Prolonged lack of air conditioning (during a heat wave)
- Lack of acclimatization
- Obesity
- Chronic diseases
 - Especially cardiovascular
 - Neurologic
 - Psychiatric
 - Endocrine, especially diabetes mellitus
 - Alcoholism
 - Skin disorders
- Acute infections/fever
- Fluid restriction/dehydration
- Drugs, especially psychotropic medications
 - Ethanol
 - Anticholinergics
 - Atropine
 - Antihistamines
 - Benztropine
 - Carbamazepine
 - Clozapine
 - Meclizine

- Tricyclic antidepressants
- Phenothiazines
- MAO inhibitors
- Diuretics
- Illicit drugs
 - Cocaine
 - Amphetamines, especially MDMA (Ecstasy)

Classic clinical signs of heatstroke include a core body temperature >105°F (40.6°C); hot, dry skin; and seizures, delirium or lethargy. Of note is that fever (as opposed to hyperthermia) rarely exceeds a core temperature of 41°C (105.8°F).

The clinical complications of heatstroke include coma, disseminated intravascular coagulation (DIC), rhabdomyolysis and acute renal failure (especially in exertional heat stroke), and severe hepatic dysfunction.

The autopsy findings of heat stroke may be minimal and are non-specific, particularly if the survival interval is short. Findings may include cerebral edema, visceral petechial hemorrhages, subendocardial hemorrhages, and hepatocyte necrosis.

The National Association of Medical Examiners (NAME) Ad Hoc Committee on the definition of heat-related fatalities recommends the following definition, “a death in which exposure to high ambient temperature either caused the death or significantly contributed to it.”²

The diagnosis should be based on a history of exposure to a hot environment and on the “reasonable exclusion of other causes of hyperthermia.”² If the antemortem core temperature was not measured when the person became incapacitated or no immediate post-mortem core temperature was measured, then the circumstances surrounding the death and the records of environmental temperature and relative humidity around the time of death can provide supportive evidence of a heat-related death.

The National Climatic Data Center (NCDC) archives data from selected weather stations, including the temperature, relative humidity and sky cover every 3 hours.⁹ The air tem-

Figure 1. Heat Index °F (°C) or “Apparent Heat”

Air Temp	Relative Humidity (%)														
	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
110 (47)	123 (51)	130 (54)	136 (58)												
108 (43)			130 (54)	137 (58)											
106 (41)			124 (51)	130 (54)	137 (58)										
104 (40)	112 (44)	116 (47)	119 (48)	124 (51)	131 (55)	137 (58)									
102 (39)	108 (42)	112 (44)	114 (46)	119 (48)	124 (51)	130 (54)	137 (58)								
100 (38)	104 (40)	107 (42)	109 (43)	114 (46)	118 (48)	124 (51)	129 (54)	136 (58)							
98 (37)	101 (38)	104 (40)	105 (41)	109 (43)	113 (45)	117 (47)	123 (51)	128 (53)	134 (57)						
96 (36)	98 (37)	100 (38)	101 (38)	104 (40)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	132 (56)					
94 (34)	95 (35)	97 (36)	97 (36)	100 (38)	103 (39)	106 (41)	110 (43)	114 (46)	119 (48)	124 (51)	129 (54)	135 (57)			
92 (33)	92 (33)	94 (34)	94 (34)	96 (36)	99 (37)	101 (38)	105 (41)	108 (42)	112 (44)	116 (47)	121 (49)	126 (52)	131 (55)		
90 (32)	90 (32)	91 (33)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	103 (39)	106 (41)	109 (43)	113 (45)	117 (47)	122 (50)	127 (53)	132 (56)
88 (31)			88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	98 (37)	100 (38)	103 (39)	106 (41)	110 (43)	113 (45)	117 (47)	121 (49)
86 (30)			85 (29)	87 (31)	88 (31)	89 (32)	91 (33)	93 (34)	95 (35)	97 (36)	100 (38)	102 (39)	105 (41)	108 (42)	112 (44)
84 (29)			83 (28)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	92 (33)	94 (34)	96 (36)	98 (37)	100 (38)	103 (39)
82 (28)			81 (27)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	88 (31)	89 (32)	90 (32)	91 (33)	93 (34)	95 (35)
80 (27)			80 (27)	80 (27)	81 (27)	81 (27)	82 (28)	82 (28)	83 (28)	84 (29)	84 (29)	85 (29)	86 (30)	86 (30)	87 (31)

Adapted from the National Weather Service. Internet Weather Source.

perature and relative humidity can then be used to estimate the Heat Index or “apparent temperature” (Figure 1). In addition, exposure to full sunshine can increase the Heat Index value by up to 15°F.¹⁰

The Heat Index has a much stronger correlation with the likelihood of heat-related illness than the air temperature alone. A Heat Index of 90°F to 105°F is categorized as *Extreme Caution*; 105°F to 129°F as *Danger* and 130°F or higher as *Extreme Danger*.¹⁰

REFERENCES

1. Cban TC, Evans SD, Clark RF. Drug-Induced Hyperthermia. *Crit Care Clin.* 1997;13(4):785–808.
2. Donoghue ER, et al. National Association of Medical Examiners Ad Hoc Committee on the Definition of Heat-Related Fatalities. Criteria for the Diagnosis of Heat-Related Deaths: National Association of Medical Examiners Position Paper. *Am J Forensic Med Pathol.* 1997;18(1):11–14.
3. Heat-Related Illnesses, Deaths, and Risk Factors—Cincinnati and Dayton, Ohio, 1999 and United States, 1979–1997. *MMWR.* 2000;49(21):470–473.
4. Heat-Related Mortality—Chicago, July 1995. *MMWR.* 1995;44(31):577–579.
5. Heat-Wave-Related Mortality—Milwaukee, Wisconsin, July 1995. *MMWR.* 1996;45(24):505–507.
6. Khosla R, Guntupalli KK. Heat-Related Illnesses. *Crit Care Clin.* 1999;15(2):251–263.
7. Mandell. *Principles and Practice of Infectious Diseases.* 5th ed. 2000:615.
8. Mirchandani HG, McDonald G, Hood IC, Fonseca C. Heat-Related Deaths in Philadelphia—1993. *Am J Forensic Med Pathol.* 1996;17(2):106–108.
9. National Climatic Data Center. Available at: <http://lwf.ncdc.noaa.gov/oa/ncdc.html>.
10. National Weather Service. Internet Weather Source. Available at: <http://weather.noaa.gov/weather/hwave.html>.
11. Simon HB. Current Concepts Hyperthermia. *N Engl J Med.* 1993;329(7):483–487.