Hyperpyrexia Due to Air-Conditioning Failure in a Nursing Home

JOHN Z. SULLIVAN-BOLYAI, MD, MPH
ROBERT M. LUMISH, MD
EDWARD W. P. SMITH, MD
JAMES T. HOWELL, MD, MPH
DENNIS J. BREGMAN, MS
MARJORIE LUND, RN, MPH
ROBERT C. PAGE, MD

HEAT STRESS without the classic symptoms of heat stroke decreases the chance of survival of the elderly and the sick (*1–3*). Experimental evidence has shown that the capacity of older persons to adapt to heat is less than that of younger persons under identical conditions of physical exertion in a controlled environment (*3*). During a heat wave in Los Angeles in 1955, an eightfold increase in expected mortality was reported for persons over 85 years of age, and a threefold increase in expected mortality was reported for persons 50–54 years old (*4*). Chronic degenerative disease in the elderly, certain therapeutic drugs such as anticholinergics and diuretics, and lack of acclimatization are thought to be additional risk factors (*3,4*).

Dr. Sullivan-Bolyai, Dr. Lumish, Dr. Smith, and Mr. Bregman were with the Bureau of Epidemiology, Center for Disease Control at the time this paper was written. Currently, Dr. Sullivan-Bolyai is with the Division of Infectious Diseases, Children's Orthopedic Hospital and Medical Center, Seattle, Wash., Dr. Lumish is in the Division of Infectious Diseases, Mercy Hospital, Pittsburgh, Pa., Dr. Smith is in the Department of Dermatology, Yale-New Haven Hospital, New Haven, Conn., Dr. Howell, Ms. Lund, and Dr. Page are with the Palm Beach County Health Department, West Palm Beach, Fla.

Tearsheet requests to Ms. Jean Heslin, Division of Viral Diseases, Center for Disease Control, 1600 Clifton Rd., Atlanta, Ga. 30333.

Heat waves increase mortality from all causes, not just from such heat-related illnesses as heat stroke and dehydration. Deaths from cerebrovascular accidents; hypertensive, arteriosclerotic, cardiovascular, and other circulatory diseases; diabetes; and chronic respiratory disease increase during urban heat waves (*2,4,5*). For patients with deficient sweat-producing mechanisms, the combination of high ambient temperatures and high humidity is the most stressful. The nature of the physiological insult is unclear. The clinical manifestations of outright heat stroke have been well described, and pathological findings are nonspecific (*4*).

Heat-related deaths not diagnosed as heat stroke constitute the majority of deaths related to heat (*5*). The physiology of these deaths has not been described. It is thought that most of these deaths are related to cardiovascular failure or other vascular complications that occur in the aged under the burden of sudden heat stress before the high body temperatures of heat stroke have been reached (*4,6*).

We have compiled evidence that supports the theory that, as a result of an air-conditioning system failure, the elderly and chronically ill residents of a nursing home suffered an episode of heat stress in August 1976 such as the general population might suffer during an urban heat wave.

Methods

Setting. The nursing home affected was 1 of 19 in a southeastern Florida county with a large elderly population. The nursing home was a single-level, clean, modern facility adjacent to a community hospital. Its patient population averaged around 90. The expected death rate was approximately one patient per week. A sudden increase in febrile illnesses among residents of the nursing home resulted in the investigation described here.

Investigation. A case was defined as an illness characterized by at least one recorded temperature (oral or rectal) greater than 38.1° C (100.6° F), with no associated symptoms. The upper limit of body temperature chosen was at least 0.3° C (0.5° F) above the accepted range of normal (*7*). Febrile patients were identified by nursing personnel and by a review of the medical records of all the nursing home residents from August 8 to 13, 1976.

Patients with fever were examined by the investigators or by private physicians. Laboratory tests and X-rays were ordered by the investigators with the consent of the respective private physicians or by the private physicians themselves. Specimens for viral isolation were processed by the Florida Department of Health and Rehabilitative Services Laboratory. The county medical examiner autopsied two persons who died during this period.

We surveyed, by questionnaire, 123 employees and volunteers who worked at the nursing home during the 2 weeks before the investigation to determine the prevalence of fever, myalgia, and respiratory and gastrointestinal symptoms. The county health department conducted a telephone survey to learn if similar illness had occurred at other nursing homes.

We interviewed nursing home personnel and a representative of the air-conditioning maintenance company about environmental conditions, specifically ambient temperatures, ventilation, and the presence of unusual or noxious odors. The county health department conducted a thorough environmental investigation, with special emphasis given to the air-conditioning and ventilation systems of the nursing home.

Results

Epidemiologic analysis. Only one febrile patient was excluded from the study—an 85-year-old man who had an upper respiratory infection and therefore did not meet the case definition.

Ten of the 89 nursing home residents had temperatures above 38.1° C (100.6° F) without other associated symptoms during 3 days, August 9–11. Five of these 10

patients died later; their temperatures had ranged from 39.4° C (103° F) to 41.3° C (106.4° F). Because of the possibility of communicable disease, isolation procedures were instituted, and the temperatures of the other nursing home residents were recorded four times a day, beginning August 11. Eight additional cases were recognized on August 12, and three more over the next 2 days. Three patients, who were hospitalized in air-conditioned facilities, returned to euthermia within 12 hours. Cases were distributed evenly among patients from both wings of the nursing home.

The mean ages were similar for persons with and without fever, as well as for those who died and survivors (table 1). Analysis of the age distribution of febrile and afebrile patients showed no significant difference between the two groups. The number of febrile patients was too small for an analysis of the age distributions of those who died and survivors.

Survey questionnaires were returned by 115 employees and volunteers. None had experienced an illness similar to that of the nursing home residents. The telephone survey of other nursing homes in the community revealed no similar illness.

Clinical, laboratory, and pathological findings. Patients' diagnoses at admission to the nursing home consisted of a wide range of chronic and degenerative diseases and their complications, without any discernible patterns to distinguish between febrile and afebrile patients. The proportion of patients with fever who had admission diagnoses of organic brain syndrome or arteriosclerotic heart disease did not differ from the proportion of patients without fever who had the same diagnoses. Eight of 21 (38 percent) febrile patients had a significant orthopedic problem, such as a fractured hip or an amputation. Thirteen of 68 (19 percent) afebrile patients had similar orthopedic problems. The probability of this distribution being due to chance is between 0.2 and 0.1 (chi-square with Yates' correction).

Patients with and without fever were compared by nonambulatory and ambulatory groups—codes 1 and 2 versus 3 and 4 (table 2). No difference was found between the groups. The proportion of patients receiving diuretics or cardiac glycosides, either alone or in combination, were compared by groups—patients with and without fever—and no differences were found. No differences were found in the use of phenothiazines and related major tranquilizers between febrile and afebrile patients or between those who died and survivors.

Occasional signs of mild dehydration and sweating were detected by physical examination of the patients. Beginning August 9, the mean temperatures of the patients who had hyperpyrexia were consistently higher than the mean temperatures of the other nursing home residents. The differences in mean body temperature between febrile patients who died and febrile patients who survived were equally consistent, as shown in the chart. When all temperatures of hyperpyrexic patients were compared with temperatures of the unaffected patients during the 7-day period of observation, the

Table 1. Mean age distribution of residents with and without fever in a nursing home, southeastern Florida, August 1976 [1]

Residents	Mean age (years)	Standard deviation
Hyperpyrexia cases:		
Patients who died	78.6	8.5
Survivors	83.9	7.6
Others	81.6	8.8

[1] Mann-Whitney U test, $P > 0.05$.

Table 2. Distribution of residents in a nursing home, by ambulation code, southeastern Florida, August 1976

Code	Hyperpyrexia cases: Patients who died	Hyperpyrexia cases: Survivors	Other residents
1: Bedridden	1	1	1
2: Confined to a wheelchair	2	8	32
3: Ambulatory, with assistance or with a walker	1	7	21
4: Fully ambulatory	1	0	14

Table 3. Laboratory data on residents with and without fever in a nursing home, southeastern Florida, August 1976

Study	Febrile patients: Number	Febrile patients: Result	Afebrile patients: Number	Afebrile patients: Result
WBC and differential	4	Normal	3	Normal
Serum NA	[1]3	Normal	0	
	[2]1	127 mEg/L	0	
Serum K	[1]4	Normal	0	
Serum Cl	[1]3	Normal	0	
	[2]1	88 mEg/L		
Serum CO_2	[1]2	Normal	0	
	[2]1	31 mEg/L		
Blood culture	7	No growth	4	No growth
Viral cultures				
Throat washing	4	No growth	1	No growth
Rectal swab	4	No growth	1	No growth
Chest X-ray	2	Normal	0	

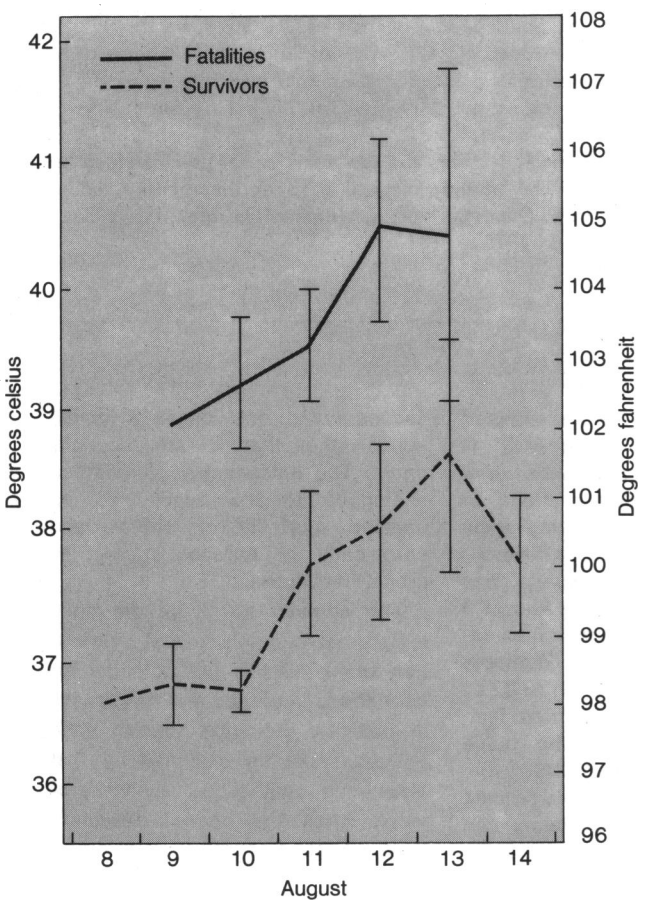
[1] Includes 1 death.
[2] Same patient, on diuretic.

distributions were significantly different ($P = 0.002$, Mann-Whitney U test).

Laboratory results are given in table 3. Autopsy results, available for two of the five patients who died, showed that in both instances hyperpyrexia was "a likely causative agent." One autopsy revealed scattered areas of "bronchopneumonia," with areas of pulmonary edema and congestion. Mild congestion of the brain and occasional extravasation of red blood cells into the brain tissue also were seen. Other findings were degenerative changes consistent with the patient's age. The second autopsy also showed foci of bronchopneumonia, with some extravasation of red blood cells into the lungs. All other findings were degenerative changes consistent with the patient's age.

Environmental findings. The air-conditioning system at the nursing home had not functioned properly since May 1976, and repair work continued throughout the summer. On August 9, refrigerant leaks in the air-conditioning system were repaired. Of the 115 employees and volunteers who were surveyed, 21 (18 percent) reported that they had noticed an unusual odor during the 2 weeks before the survey; 9 (43 percent) of these stated that they had noticed the odor on August 9. The others did not specify a time. From August 9 through late in the day of August 13, there was no forced-air ventilation because of a complete breakdown in the air-conditioning system. Circulation of air in the nursing home was poor, and only a small section of the windows could be opened.

Mean temperature of hyperpyrexic patients in a nursing home, southeastern Florida, August 8-14, 1976



The only recorded temperature in the home during August 9–13 was measured in the physical therapy room on August 11; it was 31.7° C (89° F). Weather bureau records for the 5 days showed daily peak temperatures of 32.2° C or 90° F; 32.2° C or 90° F; 31.7° C or 89° F; 31.1° C or 88° F; and 30.6° C or 87° F. Peak relative humidity rates were 94 percent, 97 percent, 99 percent, 88 percent, and 85 percent, respectively. Normal air-conditioning was restored on August 13, and measures were taken to ensure that the residents had an adequate fluid intake. Nonhospitalized febrile patients returned to euthermia within 12 hours after the air-conditioning system was repaired.

Comment

There was a temporal relationship between the complete absence of mechanical ventilation in the nursing home and the onset of elevated temperature among the residents. Mean temperatures for both febrile and afebrile patients showed sustained rises after August 10, peaked on August 13—the day that the air-conditioner was repaired—and fell to normal levels by the following day. Febrile patients who were moved to the air-conditioned hospital promptly defervesced. The extremely high temperatures of the persons who died and their consistently higher mean temperatures than those of the survivors were also consistent with the diagnosis that the deaths were related to the extremely high environmental temperatures of the nursing home.

Physical examinations and laboratory studies failed to reveal evidence for etiologies other than heat. The finding of patchy bronchopneumonia in the two postmortem examinations does not rule out death from hyperpyrexia. The edema and extravasation of red blood cells found in the brain of one subject and the lungs of another are consistent with the diagnosis of heat stroke (*4*). Chest X-rays of two patients with fever and physical examinations of the other febrile patients showed no evidence of pneumonitis.

Age and sex were unrelated to the risk of hyperpyrexia in this outbreak.

The distribution of significant orthopedic problems suggested that patients who were less ambulatory were

at higher risk of having fever than those who were more ambulatory; however, the distribution of the ambulation groups failed to support the hypothesis.

Neither diagnosis at admission nor patterns of diuretic or cardiac-glycoside use were significantly different between febrile and afebrile patients; therefore, cardiovascular illness did not appear to be a risk factor. Phenothiazines have been reported to cause acute episodes of malignant hyperthermia (*8*). The anticholinergic properties of these drugs theoretically could interfere with sweating, and patients who take them would be at increased risk of becoming hyperthermic. However, patterns of phenothiazine use were not significantly different between febrile and afebrile patients in this outbreak.

Heat stress as a result of air-conditioning failure is the best explanation for the hyperpyrexia and increased mortality suffered by the elderly and chronically ill residents of the nursing home. The patients were unable to compensate physiologically because of their advanced age, chronic diseases, and lack of acclimatization, since the nursing home was normally air-conditioned. Twenty-three percent of the nursing home residents had a body temperature of 100.6° F or higher without accompanying signs or symptoms; 24 percent of the residents who had fever died. The deaths caused approximately a fivefold increase in the expected mortality of the nursing home. The nonspecific nature of the deaths is consistent with the nonspecific increase in mortality among the aged and chronically ill that has occurred in previous urban heat waves.

This episode points up the need for prompt recognition and intervention when there is the potential for heat stress in elderly and chronically ill patients. Liquids should be administered frequently, and the amounts ingested should be recorded. Adequate air circulation must be assured. If an air-conditioning system malfunctions, windows should be opened and electric fans should be used to assure air circulation. Buildings housing elderly and chronically ill patients must be designed so that alternative ventilation can be provided when the central air-conditioning system fails.

References

1. Macpherson, R. K., and Ofner, F.: Heat and the survival of the aged and chronically ill. Med J Aust 1: 292–295 (1965).
2. Schuman, S. H., Anderson, C. P., and Oliver, J. T.: Epidemiology of successive heat waves in Michigan in 1962 and 1963. JAMA 189: 733–738 (1964).
3. Lind, A. R., and Henschel, A.: Standard for occupational exposures to hot environments. National Institute for Occupational Safety and Health, Cincinnati, Ohio, 1976, pp. 9–19.
4. Shibolet, S., Lancaster, M. C., and Danon, Y.: Heat stroke: a review. Aviation Space Environ Med 47: 280–301 (1976).
5. Ellis, F. P.: Mortality from heat illness and heat-aggravated illness in the United States. Environ Res 5: 1–58 (1972).
6. Burch, G. E., and Miller, G. B.: The effects of warm, humid environment on patients with congestive heart failure. South Med J 62: 816–822 (1969).
7. Petersdorf, R. G.: Alterations in body temperature. *In* Harrison's principles of internal medicine, edited by G. W. Thorn, et al. McGraw-Hill Book Co., Inc., New York, 1977, p. 54.
8. Byck, R.: Drugs and the treatment of psychiatric disorders. *In* The pharmacological basis of therapeutics, edited by L. S. Goodman and A. Gilman. The MacMillan Co., New York, 1975, p. 164.

SYNOPSIS

SULLIVAN-BOLYAI, JOHN Z. (Center for Disease Control), LUMISH, ROBERT M., SMITH, EDWARD W. P., HOWELL, JAMES T., BREGMAN, DENNIS J., LUND, MARJORIE, and PAGE, ROBERT C.: *Hyperpyrexia due to air-conditioning failure in a nursing home. Public Health Reports, Vol. 94, September–October 1979, pp. 466–470.*

During the period August 9–13, 1976, 21 of 89 residents of a nursing home in southeastern Florida had sudden onset of fever—temperature >38.1° C (100.6° F) with no accompanying symptoms. Five residents, whose temperatures ranged from 39.4° C (103° F) to 41.3° C (106.4° F), died. No viral or bacterial pathogens were isolated. None of the nursing home's 123 employees and volunteers had similar illness.

The air-conditioning system was shut down for repairs from August 9 through August 12, a time when recorded peak temperatures outdoors ranged from 30.6° C (87° F) to 32.2° C (90° F). The only recorded temperature inside the nursing home for that period was 31.7° C (89° F).

Laboratory and epidemiologic data were consistent with the theory that the illness was due to hyperpyrexia, secondary to environmental conditions, rather than to an infectious agent. The episode was considered analogous to the nonspecific increased mortality of elderly and chronically ill persons during an urban heat wave.

The episode points up the need for prompt recognition and intervention when there is the potential for heat stress in elderly and chronically ill patients. Buildings housing such patients must be designed so that alternative ventilation can be provided when the central air-conditioning system fails.