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# Rapid Onset of Severe Heat Illness: A Case Report (Reprint)

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Aviators flying extended periods in hot environments are known to be at risk for heat-related illness. The risk when wearing chemical individual protective equipment (IPE) is increased even at relatively warm temperatures and light workloads. In this paper, we report the physiological responses of an aviator who had been flying a UH-1H helicopter up to 6 h/d clothed in full IPE on 6 consecutive days prior to the sudden onset of heat illness. His performance during the study was normal, and no clear physiological derangements were noted prior to his symptoms. The rapid evolution of his symptoms after voicing no complaints provides a graphic illustration of the difficult predictability and initial central nervous system effects of this condition.

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## CLINICAL MEDICINE

# Rapid Onset of Severe Heat Illness: A Case Report

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**Aviators flying extended periods in hot environments are known to be at risk for heat-related illness. The risk when wearing chemical individual protective equipment (IPE) is increased even at relatively warm temperatures and light workloads. In this paper, we report the physiological responses of an aviator who had been flying a UH-1H helicopter up to 6 h/d clothed in full IPE on 6 consecutive days prior to the sudden onset of heat illness. His performance during the study was normal, and no clear physiological derangements were noted prior to his symptoms. The rapid evolution of his symptoms after voicing no complaints provides a graphic illustration of the difficult predictability and initial central nervous system effects of this condition.**

IN GENERAL, efforts to provide predictable limits of an aviator's ability to pilot an aircraft during high thermal stress have been based on physiological responses to that heat. However, a particular individual's onset of performance decrement is not predictable from a determination of rectal temperature alone. Although hypohydration is well known to cause decrements in performance, the existing level of hydration may be difficult to assess under operational conditions. Additional problems of real world variability of environment, workload, and performance requirements make the overall problem of reliably predicting significant decrements in an individual appear impossible to the practicing flight surgeon.

Despite these limitations, a study was undertaken at the U.S. Army Aeromedical Research Laboratory during the summer of 1984 to obtain physiological, psychological, and performance data on rotary wing aviators during an operational scenario. A report of the entire study is available (5). This paper reports the sudden collapse of one of the subjects after the second flight on the last day of his 6-day participation.

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## METHODS

### *Subject*

A 32-year-old Caucasian male active duty aviator (height 175 cm, weight 79.6 kg, $\dot{V}O_{2max}$ 43.6 $ml \cdot min^{-1} \cdot kg^{-1}$) stationed at the Army Aviation Center, Fort Rucker, AL, volunteered as a subject (S) in the study mentioned above. His rotary wing flight experience was 800 h. He had no prior history of heat illness (syncope, exhaustion or stroke) and had normal physical findings on a thorough history and examination conducted by a flight surgeon immediately preceding participation in the study.

He did not acclimatize beyond his usual 1 h daily physical exercise program in gym clothing. His routine blood chemistries from the beginning of the first day of participation in the study were: sodium 141 mg/dl; potassium 4.3 mg/dl; chloride 103 mg/dl; bicarbonate 33 mg/dl; glucose 72 mg/dl; urea nitrogen 15.2 mg/dl; white blood cell count 4900 cu/mm; hemoglobin 13.7 g/dl; hematocrit 42.3%. All values were within the local hospital laboratory's normal ranges.

### *Physiologic Data Collection*

During flights, the subject's heart rate and rhythm were recorded continuously by an ambulatory electrocardiographic monitor (Hittman Medical Systems, Columbia, MD). Body temperature was obtained by a rectal probe (Yellow Springs Instruments Inc. model 701B, Yellow Springs, OH) inserted to 10 cm. Body temperature and heart rate were recorded manually by observation at 5 min intervals on a digital output meter (Tektronix Inc. model 414, Beaverton, OR). Cockpit environmental temperatures—dry bulb ($T_{db}$), wet bulb ($T_{wb}$), and globe ($T_{bg}$) temperatures—were determined at the same times using a WBGT meter (Reuter-Stokes Canada Ltd. WIBGET, Cambridge, Ont., Canada) placed between the pilots' seats at the subject's head level.

Net fluid balance was determined by beginning- and end-of-test-day uniform and nude body weight measurements on an electronic balance (Sauter model K120, August Sauter, Div. of Metler Instruments, Hightstown, NJ) and by weighing all oral fluid intake and urine output.

### *Individual Protective Equipment*

The U.S. Army's chemical defense ensemble (1984) consists of a two-layer, two-piece overgarment with butyl rubber overboots and gloves and M-24 mask with hood worn over the standard Nomex one-piece flight suit, gloves, and helmet. A prototype microclimate cooling vest was worn under the flight suit. The ensemble (without cooling vest) exhibits a clo value of 2.57 and an index of permeability of 0.29 (3).

### *Mission Protocol and Test Facility*

This study was conducted under simulated field operational conditions during the summer of 1984 at Highfalls Stagefield, Fort Rucker, AL. During daylight hours, the S flew a UH-1H "Huey" helicopter, received pre-mission briefings, and performed pre- and through-flight checks on the aircraft. No re-arming or refueling tasks were performed by the S. Full IPE was maintained during the entire period from breakfast to the end of the final daily test period (approximately 12 h). During the remainder of the time, he relaxed in a small field tent while wearing only open overgarments over his flight suit. Breakfast and supper were provided as Meals-Ready-to-Eat (MREs), but midday intake was limited to a flavored electrolyte and glucose solution. Water was allowed *ad libitum*.

Flight profiles included low level, nap-of-the-Earth (NOE), confined area operations, instrument approaches and other tactical situations such as reconnaissance missions. No gross performance deficits were found on any of the flights during the entire week.

A microclimate air-cooling vest was used during days 3 and 4 of the study. The S experienced no significant increases in rectal temperature during any flights on these days. Significantly, he (unlike other Ss in the study) flew with all aircraft doors closed on all days (except day 5) which increased the level of heat buildup in the cockpit by further reducing convective heat dissipation and evaporation.

## RESULTS

### *Cardiovascular System*

S did not exceed a heart rate of 120 bpm (mean 91 ± 11) which is less than that often seen with even moderate exercise. Peak and mean heart rates during each flight are shown in Table I. No significant correlation was found between heart rate and cockpit temperature except during the two hottest flights without cooling. The rates observed were consistent with previous estimates of the work load of helicopter pilots (160 to 180 W) during flight (9).

### *Thermoregulation*

Peak and mean rectal temperatures and mean cockpit WBGT for each flight during the entire week are also displayed in Table I. Flights terminated by the flight surgeon for maximum rectal temperature by safety criteria (N = 2) are denoted by the symbol "T," and those terminated for the subject's own complaints (nausea and fatigue) by the symbol "M" (N = 1). Completed flights are noted by the symbol "C," except for days 3, 4 and 5 when the last flight of the day was determined by either equipment problems ("E") or weather ("W"), respectively. Regression of peak rectal temperature by mean cockpit WBGT yielded a correlation coefficient r = 0.89. Detailed data for the day of the clinical episode are shown in Fig. 1.

### *Fluid Balance*

Daily weight changes for this subject and his equipment are displayed in Table II. Body loss is the differ-

TABLE I. RECTAL TEMPERATURE, HEART RATE AND COCKPIT WBGT (PEAK/MEAN) BY DAILY FLIGHT NUMBER, DURATION AND REASON FOR FLIGHT END.*

| Day No. | Flight No. | Duration (h:m) | Stop Reason | Rectal Temp (°C) | Heart Rate (bpm) | Cockpit WBGT (°C) |
|---|---|---|---|---|---|---|
| 1 | 1 | 1:23 | C | 37.8/37.6 | 100/89 | 29.7/28.1 |
| | 2 | 0:53 | M | 37.9/37.6 | 97/91 | 31.9/30.1 |
| 2 | 1 | 1:25 | C | 37.6/37.4 | 99/84 | 30.4/27.3 |
| | 2 | 1:25 | C | 38.4/38.0 | 110/92 | 31.4/29.9 |
| | 3 | 0:40 | T | 38.5/38.3 | 100/101 | 31.2/30.1 |
| 3† | 1 | 1:30 | C | 37.2/37.1 | 74/69 | 29.4/28.6 |
| | 2 | 1:18 | C | 37.4/37.3 | 83/72 | 32.9/30.3 |
| | 3 | 1:25 | E | 37.3/37.2 | 85/69 | 33.2/30.7 |
| 4† | 1 | 1:20 | C | 37.3/37.2 | 80/71 | 30.6/28.8 |
| | 2 | 1:30 | C | 37.0/37.0 | 79/70 | 34.6/32.5 |
| | 3 | 0:47 | W | 37.3/37.3 | 89/78 | 31.9/30.7 |
| 5 | 1 | 1:20 | C | 37.3/37.2 | 82/69 | 26.7/25.9 |
| | 2 | 1:24 | C | 37.3/37.2 | 68/62 | 28.0/25.9 |
| | 3 | 1:30 | C | 37.4/37.2 | 68/60 | 29.2/26.0 |
| | 4 | 0:45 | E | 37.1/37.0 | 76/62 | 25.8/24.1 |
| 6 | 1 | 1:30 | C | 37.5/37.3 | 92/80 | 30.5/29.1 |
| | 2 | 1:02 | T | 38.5/38.0 | 98/87 | 32.6/31.0 |

* See text for explanation of symbols
† Cooling vest in use

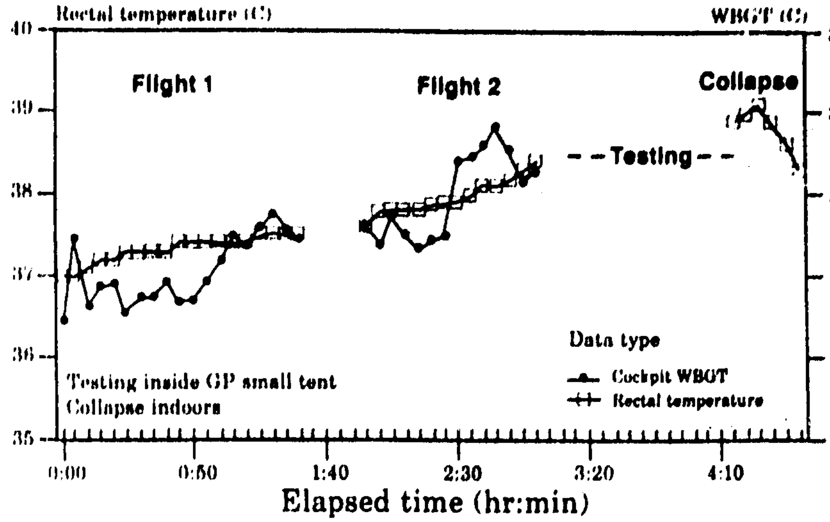


**Fig. 1. Cockpit WBGT and subject rectal temperature by elapsed time on last study day.**

TABLE II. MEAN DAILY FLUID BALANCE SUMMARY

| Day No. | Oral Intake (L) | Urine Output (L) | Uniform Gain (kg) | 12-h Body Loss (kg) | 24-h Body Loss (kg) |
|---|---|---|---|---|---|
| 1 | 4.81 | 0.76 | 1.29 | 0.22 | −0.83 |
| 2 | 7.70 | 2.34 | 2.52 | 0.32 | 1.31 |
| 3 | 7.01 | 1.52 | 0.85 | −0.01 | 0.59 |
| 4 | 3.06 | 0.87 | 0.19 | 0.92 | 0.26 |
| 5 | 3.09 | 1.26 | 0.31 | 1.07 | 0.13 |
| Mean | 5.13 | 1.35 | 1.03 | 0.70 | 0 |

ence between successive morning nude weights, and uniform gain is the difference between morning and end-of-flight day total uniform weights. Daily intake and output of fluids are also shown.

Data are shown only for the first 5 d of the test period since the last day was terminated in the early afternoon and did not allow 12- or 24-h weight changes and intake/output determinations. On the last day (about 7 h), S drank 2.93 L of water, produced 0.71 L of urine, had a 1.82-kg gain in uniform weight, and had a net loss of 1.28 kg in body weight.

*Clinical Episode*

S reached the medical safety termination rectal temperature of 38.5°C at the conclusion of the second flight on the last day. He expressed disappointment that he was unable to complete the entire day. He repeatedly asked to continue flying in the afternoon and denied any recurrence of fatigue or nausea he had earlier in the week. S appeared physically tired, but his behavior was entirely appropriate.

Continuation of the flying day was denied due to the protection of human subjects protocol in effect. His next hour was spent in a small general purpose tent, still in full IPE, taking a computerized psychological test battery as part of the study. This had been done at the termination of every flying day. On exiting the tent, S again expressed his desire to continue flying. The flight medic then began to assist him with undressing and terminal data collection inside an air conditioned command building on-site.

Within approximately 5 min, the medic urgently requested medical assessment of S. S's mask and hood were off, and he had tears streaming down his cheeks. When asked what was going on, he began to answer with a distinct stutter. S verbalized a few words about "letting us down" and then stopped responding to questions and began staring vacantly at the walls. This abnormal behavior was assumed to be heat-related, and undressing proceeded rapidly. As his upper body clothing was removed, the skin on his arms and chest became mottled. A radial pulse could not be palpated, and S collapsed. He was unresponsive to voice or painful stimulation.

Fortunately, the dressing area also served as the emergency treatment area, and S was placed on the treatment table while the remainder of his clothing was removed. Ice packs were placed on his neck and in his armpits and groin. Water mist was sprayed from a garden-type device, and air was circulated over him by a fan. Temperature data was read and recorded several times during this episode. Even as intravenous access was being established, he began to speak and move his extremities. Within a 10-min period, he became completely oriented with normal vital signs and physical examination.

The continuing slow rise in rectal temperature observed during the flight day is illustrated in Fig. 1, as is the rapid rise after the psychological testing period and the equally rapid fall with treatment. Physical examination and routine laboratory values immediately after recovery were normal (sodium 141 mg/dl, potassium 4.0 mg/dl, chloride 102 mg/dl, bicarbonate 32 mg/dl, glucose 107 mg/dl, urea nitrogen 14.2 mg/dl, white blood cell count 5100, hemoglobin 14.1 g/dl, hematocrit 42.6%). CK enzyme values were, unfortunately, not obtained. Urine electrolyte analysis revealed sodium 58 mg/dl, potassium 45 mg/dl, and chloride 24 mg/dl with negative presence of myoglobin immediately after the episode. S had no memory of events from the postflight psychological testing until becoming aware that he was "being assaulted" in the treatment room. Follow-up examinations remained normal, a d he remained on active flying status without sequelae.

## DISCUSSION

The actual pathophysiology of the clinical episode remains unclear (1). The possibility of heat syncope certainly is significant, although it is usually seen earlier in the course of heat exposure in less acclimated persons. Heat stroke did not appear to develop here, although the rapid rise in rectal temperature provides some question that it may have been the onset of this condition. The loss of potentially confirmatory enzyme levels is frustrating. Heat exhaustion and hypohydration is most probable since his rectal temperature had been elevated for several hours beforehand, and there was an observed net weight loss of 1280 g during the period from breakfast to the clinical episode (about 7 h).

The actual diagnosis does not matter for flying safety considerations, however. Rapid onset of severe performance decrements with few, but recognizable, early warning signs is the central focus. This aviator tried to convince the flight surgeon that he could fly again just minutes prior to losing consciousness. Without rectal temperature readings and protocol restrictions, as is the case in real world operations, he might have been medically cleared to continue flying. What then?

The central nervous system signs S exhibited prior to collapse are typical signs of the onset of severe heat illness and are a key to survival for the rest of the aircrew (2). The inappropriate affect, presence of speech changes, and finally inattention or withdrawal are recognizable by alert fellow aircrew members. Each must be aware of the potential signs and must be ready to transfer control of the aircraft as necessary. In case an aircrew member suffering from heat effects has an inflight physiological emergency, the whole crew must be knowledgeable about effective field treatment for acute heat illness, since medical facilities may not be readily available.

Most clothing and equipment can be removed or at least opened even in flight prior to landing. Chemical cold packs which activate on crushing are small enough to fit in personal flight bags during the summer months or on IPE operations. They are applied easily to areas where arteries are close to the surface (neck, armpits, and groin) and cool the blood efficiently (10). Canteen water splashed on exposed skin can be evaporated by fanning with a jacket or shirt or exposing him to the wind or rotor downwash (4,6). Shivering should be avoided since it raises the body temperature, so treatment needs to be tailored to the situation (7). This treatment regimen can be administered to any aircrew member with active signs of heat illness, although the initial measures alone may be sufficient to alleviate the condition. The bottom line is that all aircrew members need to be aware of this problem, its manifestations, and its immediate treatment if preventive measures fail.

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Human subjects participated in these studies after giving their informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 for use of volunteers in research.

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## REFERENCES

1. Armstrong LE, Hubbard RW, Szlyk PC, Sils IOV, Kraemer WJ. Heat intolerance, heat exhaustion monitored: a case report. Aviat. Space Environ. Med. 1988; 59:262–6.
2. Carter BJ, Cammermeyer M. A phenomenology of heat injury: the predominance of confusion. Milit. Med. 1988; 153:118–26.
3. Knox FS, Nagel GA, Hamilton BE, Olazabal RP, Kimball KA. Physiological impact of wearing aircrew chemical defense protective ensembles while flying the UH-1H during hot weather. Fort Rucker, AL: USAARL, 1981; Report No. 81-4.
4. Larkin JT. Treatment of heat-related illness (letter). J.A.M.A. 1981; 245:570.
5. Mitchell GW, Knox FS, Edwards RE, Schrimsher RR, Siering G, Stone LW, Taylor PL. Microclimate cooling and the aircrew chemical defense ensemble. Fort Rucker, AL: USAARL, 1986; Report No. 86-12.
6. Poulton TJ, Walker RA. Helicopter cooling of heatstroke victims. Aviat. Space Environ. Med. 1987; 58:358–61.
7. Rubenstein E. Heatstroke. In: Rubenstein E, Federman, eds. Scientific American Medicine. NY: Scientific American, Inc 1989, 8 Interdisc V:1-2.
8. Szlyk PC, Sils IV, Francesconi RP, Hubbard RW, Matthew WT. Variability in intake and dehydration in young men during a simulated desert walk. Aviat. Space Environ. Med. 1989; 60:422–7.
9. Thornton R, Brown GA, Higenbottam C. The energy expenditure of helicopter pilots. Aviat. Space Environ. Med. 1984; 55:746–50.
10. Abramowicz M, ed. Treatment of heat stroke. Med. Lett. Drug Ther. 1981; 23:63

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