



London Health Sciences Centre
Southwest Ontario Regional Base Hospital Program



Heat Illness

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Objectives

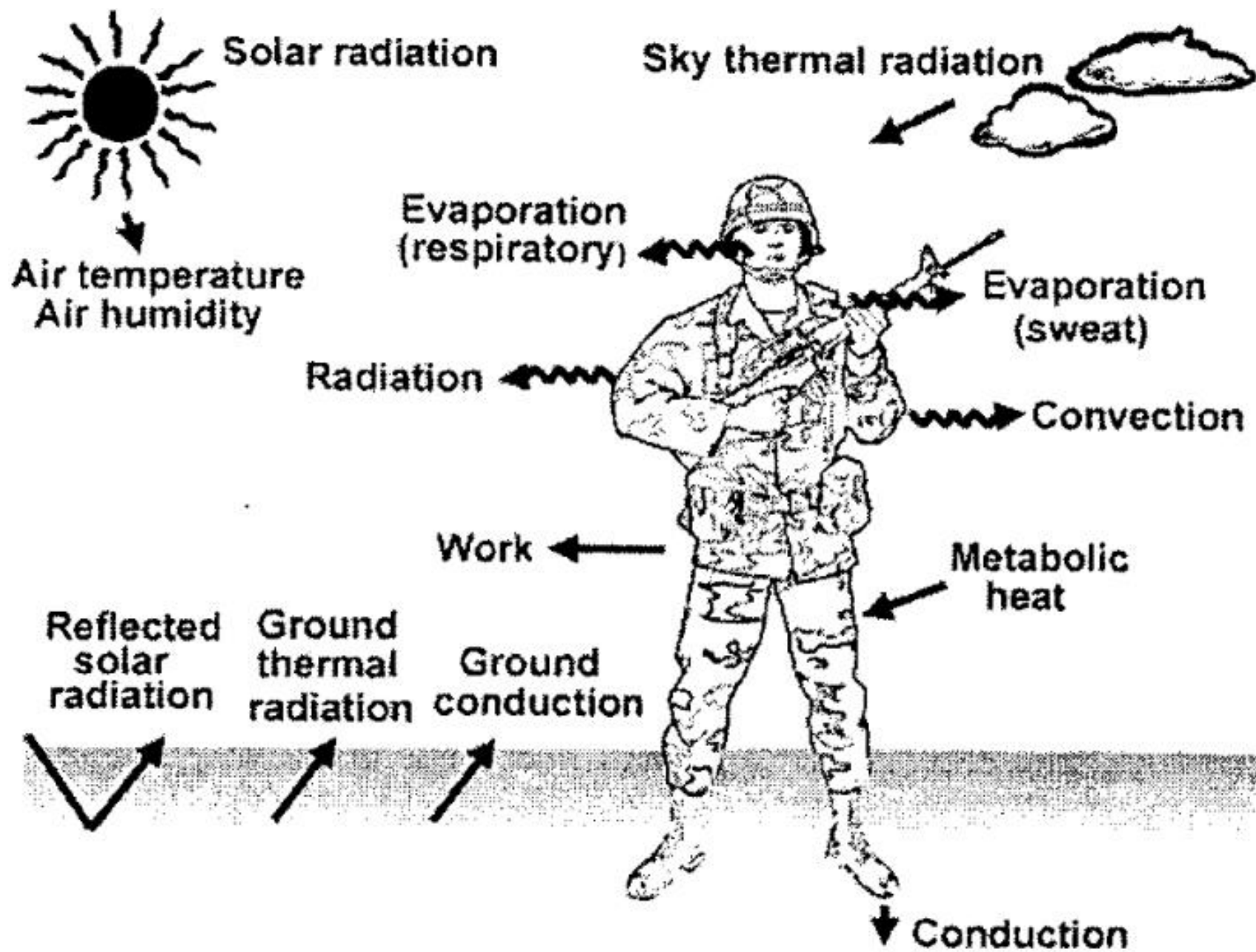
- Physiology and pathophysiology
- Risk factors and prevention
- Various heat disorders
- Heat illness in BLS & ALS PCS



Physiology and Pathophysiology

Mechanisms of Heat Transfer

- 1) Conduction – By direct physical contact (ex. object)
- 2) Convection – Through air and water molecules beside the body (ex. swimming)
- 3) Radiation – By electromagnetic waves (ex. sun)
- 4) Evaporation – Conversion of liquid to a gas (ex. sweat)



EVAPORATION: PERSON IS SWEATING AND LOSING HEAT INTO THE AIR

CONDUCTION: BODY HEAT TRANSFERRED TO SOMETHING IN CONTACT WITH THE HUMAN BODY

CONVECTION: COOL AIR MAKES CONTACT WITH THE BODY; BODY HEAT WARMS THE AIR WHICH IS CARRIED AWAY BY CONVECTION CURRENTS (IN THE PROCESS, THE BODY LOSES HEAT)

RADIATION: BODY LOSES HEAT TO TABLE BY MOVEMENT OF HEAT WAVES FROM WARMER BODY TO COOLER TABLE



Mechanisms of Heat Transfer

- Thermal conductivity of water is 25x greater than air
- Once air temp $>$ body temp, heat is gained instead of lost by convection
- Radiation accounts for 65% of heat loss in cool environments, but is a source of heat gain in hot climates
- Evaporation becomes more important for heat loss as temps rise

Ever wonder why dogs pant?



- Some mammals like dogs have an oropharyngeal countercurrent flow mechanism
- Dogs pant at 300–400 bpm (cool air in, hot air out)
- Panting also increases evaporation from the upper respiratory tract

Heat Regulation

- Thermosensors
 - Peripheral (skin) and central (hypothalamus)
- Central integrative area
 - Central thermostat
- Thermoregulatory effectors
 - Sweating, peripheral vasodilation

Acclimatization

- Physiologic adaption after repeated heat exposure
- Daily exposure to working in a hot environment for 100 min / day for 1–2 weeks
- Easier to acclimatize with a low salt diet
- Acclimatization is quick (to achieve, and to lose)

Acclimatization

- Plasma volume expansion
- Improved cutaneous blood flow
- Earlier onset of sweating (ie. at a lower body temp)
- Increased sweat volume
- Lower sweat electrolyte concentration

Fever vs. Hyperthermia

- Fever – Elevated body temperature from a reset thermal set point in the hypothalamus
- Hyperthermia – Elevated body temperature from failed thermoregulation

Fever vs. Hyperthermia

- Fever – Treat with antipyretics
- Hyperthermia – Whole-body cooling
- Trying to cool a febrile patient will cause violent shivering and discomfort
- Similarly, antipyretics will not help a hyperthermic patient



**“IF YOU SAW A HEAT WAVE, WOULD YOU WAVE
BACK?”**

STEVEN WRIGHT

© Lifehack Quotes

Risk Factors and Prevention

Risk Factors for Heat Illness

- Elderly
- Children
- Mental illness
- Chronic diseases (ex. heart disease, diabetes)
- Skin disorders
- Medications (ex. B-blockers, CCB, anticholinergics)
- Drug use (ex. cocaine)
- Dehydration
- Exercise in hot environment (ex. military, athletes)
- Obesity

Preventative Measures

- Wear loose-fitting or ventilated clothing
- Wear light-coloured clothing
- Stay hydrated with cool, low osmolality fluids
- Use work-rest cycles

Fluid Intake

- The goal is to increase gastric emptying – Want fluid to reach the small intestine where it is absorbed
- Factors that promote gastric emptying:
 - Large fluid volume (> 500 mL)
 - Cool temps ($10-15^{\circ}$ C)
 - Low osmolality (< 200 mOsm/kg)

Fluid Intake – Osmolality

- Water: 0 mOsm/kg
- Blood: 290 mOsm/kg
- Gatorade: 350–400 mOsm/kg
- Powerade: 400–430 mOsm/kg
- Pedialyte: 250–270 mOsm/kg

Remember during the heat wave to stay indoors and exert minimal energy like every other day of your life.

somee cards



Heat Illnesses

Heat Illnesses

Minor	Major
Heat cramps	Heat exhaustion
Heat edema	Heat stroke
Heat syncope	
Prickly heat	

Heat Cramps

- Brief, intermittent, severe muscle cramps in heavily worked muscles
- Muscle cramps develop after work in a hot environment
- Cause: Salt deficiency

Heat Cramps

- Clinical clues:
 - Occur after exertion (not during)
 - Copious sweating during exertion
 - Drinking lots of hypotonic fluid (leading to ↓ Na)
 - Systemically well
- Different than the cramps athletes experience during exercise, which are shorter-lived and resolve spontaneously

Heat Cramps

- Treatment: Salt solutions (ex. electrolyte drinks, NS bolus)
- Salt tablets delay gastric emptying and are not recommended

Heat Edema

- Mild feet and ankle swelling in non-acclimatized patients
- Occurs after prolonged sitting or standing
- No underlying cardiac, hepatic, venous, or lymphatic disease

Heat Edema

- Cause: Cutaneous vasodilation and orthostatic pooling lead to accumulation of fluid in the lower extremities
- Clinical clue:
 - No functional impairment – The patient is well otherwise

Heat Edema

- Always consider other causes for leg edema (DVTs, CHF, lymphedema, etc.)
- Treatment: Leg elevation, support stockings
- Will resolve with acclimatization or return to temperate climate (ie. by the time your vacation is over)

Heat Syncope

- Temporary LOC in a hot environment
- Cause: Peripheral venous pooling, volume loss, peripheral VD lead to ↓ venous return and ↓ cerebral perfusion → Syncope
- Many causes of syncope – Heat syncope is a diagnosis of exclusion

Heat Syncope

- S&S:
 - Lightheadedness
 - Tunnel vision
 - Pale and sweaty skin
 - Bradycardia
 - Normal or near-normal temp

Heat Syncope

- Treatment: Horizontal position
- Prevention is key:
 - Do not stand for prolonged time in the heat
 - Flex leg muscles often to increase venous return
 - Lie down if prodromal symptoms occur

Prickly Heat

aka. miliaria rubra, lichen tropicus, heat rash

- Acute inflammatory disorder of the skin in tropical climates
- Cause: Blocked sweat gland pores with dead skin cells become secondarily infected by *staphylococcus*

Prickly Heat

1) Acute Phase

- Dilation and rupture of obstructed sweat glands
- Produces intensely pruritic vesicles on an erythematous base
- Rash confined to clothed areas
- Sweat glands can be entirely blocked leading to anhidrosis in that area



Prickly Heat

2) Profunda Phase

- Keratin plug fills vesicles and causes deeper obstruction of the sweat gland
- 2nd rupture occurs, producing deeper vesicle in the dermis
- Lasts for weeks
- No pruritus (unlike acute phase)



Prickly Heat

- Treatment:
 - Chlorhexidine cream or lotion
 - Salicylic acid 1% topical (caution salicylate toxicity)
 - Erythromycin
- Prevention: Light, loose-fitting, clean clothing
- Routine use of talcum or baby powder should be avoided

Major Heat Illnesses

Death

Heat Stroke

Heat Exhaustion



Heat Exhaustion

- Volume depletion and fatigue under conditions of heat stress
- Water depletion vs. salt depletion
- Clinical features:
 - Malaise, fatigue
 - Headache, N/V, vertigo
 - Normal or low-grade temp
 - Tachycardia, orthostatic hypotension, dehydration
 - Diaphoresis

Heat Exhaustion

- What they do not have:

- Temp $\geq 40^{\circ}$ C
- Altered mental status
- Seizure
- Coma

- Treatment:

- Rest from the environment
- Fluids (PO or IV) based on clinical volume assessment and serum electrolytes

Heat Stroke

- Life-threatening condition with body temperature $\geq 40.5^{\circ}$ C resulting from failed homeostatic thermoregulatory mechanisms
- Multisystem tissue damage and organ dysfunction
- While body temp may rise in other heat illnesses, the thermoregulatory mechanisms fail in heat stroke

Heat Stroke

- At first, heat is dissipated from peripheral VD
- Hypovolemia is avoided by compensatory splanchnic and renal VC
 - Explains the universal hepatic damage in heat stroke
- When thermoregulatory compensation fails, heat storage rises dramatically
- \uparrow ICP and \downarrow MAP leads to \downarrow cerebral blood flow (bad)

Heat Stroke

- Tissue damage depends on temperature and duration of exposure
- Clinical features:
 - Exposure to heat stress
 - CNS dysfunction (coma, seizure, delirium)
 - Core temp usually $\geq 40.5^{\circ}$ C
 - Hot skin \pm sweating
 - N/V/D
 - Marked elevation of hepatic transaminases
- Neurologic dysfunction is the hallmark of heat stroke

Heat Stroke

- Heat exhaustion can progress to heat stroke
- Onset is sudden in 80% of cases of heat stroke
- Interesting that 50% of patients continue to sweat (so loss of sweat mechanism is not the cause)

Heat Stroke

- Taking a temperature in the field can be very helpful to hospital staff!
- By the time patients reach the hospital, significant cooling may have taken place

Heat Stroke

Classic	Exertional
Elderly, poor, vulnerable population	Athletes, military recruits
Underlying medical conditions	Generally healthy
During heat waves	During intense exercise
Sweating often ceases	Sweating often persists
Myocardial enzyme release	Renal failure and rhabdomyolysis
Respiratory alkalosis	Lactic metabolic acidosis

Heat Stroke

- What else could it be?
 - Meningitis / encephalitis
 - Cerebral falciparum malaria
 - Thyroid storm
 - Drug-induced (sympathomimetics, anticholinergics)
 - Typhoid fever
 - Delirium tremens
 - Hypothalamic hemorrhage
 - Malignant hyperthermia
 - Neuroleptic malignant syndrome or serotonin syndrome

Treatment of Heat Stroke

Cooling

- Immediate cooling is the cornerstone of treatment
- Heat stroke has a mortality of 21–63%

Cooling

All Pre-Hospital Environments	Hospital
Remove patient from hot environment	Remove clothes
Initiate cooling	Continuous core temperature monitoring
Loosen tight clothing	Body cooling unit
Remove excess clothing	Atomized water at 40° C and cooling fans
Use fans / wind	Immersion in ice water to < 39° C
Use AC where available	Cooling blankets
Cover in wet sheets	BZDs for shivering
Ice packs to neck, groin, axillae	Cardiopulmonary bypass

Resuscitation

- Aspiration – Airway management
- Seizures
- Hypoxemia
- Pulmonary edema vs. hypotension (dehydration, peripheral VD)
- Tachydysrhythmias

May your outdoor
summer wedding
be filled with
minimal heat
stroke fatalities.



som^{ee}cards

BLS PCS on Heat-Related Illness

Heat-Related Illness

- Consider heat-related illness in a hot environment with any of the following complaints:
 - Fainting or syncope
 - Muscle cramps
 - Non-specific complaints (headache, N/V, malaise)
 - Excessive sweating or dry skin
 - Fever
 - Altered mental status
 - TCA, antihistamine, beta-blocker, cocaine, amphetamine OD

Heat-Related Illness

- Assume the potential for life threats from heat stroke or hypovolemic shock
- Scene survey and primary survey
- Make a transport decision
- Initiate cardiac monitoring

Heat-Related Illness

- History and physical exam
- If heat stroke suspected → Head-to-toe survey
- Otherwise, do a focused exam:
 - Vital signs
 - CNS – GCS, pupils
 - Mouth/skin – Dehydration, skin temp, colour, condition
 - Extremities – Inspect, palpate if muscle cramps

Heat-Related Illness: General Management

- Move patient to cooler environment
- Position supine if syncope, hypotension, shock
- Remove heavy or excess clothing
- Massage cramped muscles
- Consider small quantity of salt-containing fluid PO

Heat-Related Illness: Heat Exhaustion

- Administer high concentration O₂
- Implement rapid cooling if temp seems very high:
 - Move patient to ambulance and remove as much clothing as possible
 - Turn AC on high
 - Cover patient with wet sheets
 - Massage extremities to increase VD and prevent shivering
 - Transport minimum priority Code 3

Heat-Related Illness: Heat Stroke

- Administer high concentration O₂ and initiate rapid transport
- Implement rapid cooling as per previous slide, plus:
 - Withhold oral fluids
 - Apply cold packs to axillae, groin, neck, and head
 - Use minimum force required to restrain a combative patient
 - Manage seizures, emesis, shock, agitation, coma, cardiac arrest

Heat-Related Illness: Management

- If transport time $>$ 30 min, continually reassess patient to determine when cooling should be discontinued:
 - Skin temp feels normal
 - Shivering develops
 - LOC improves

ALS PCS Medical Directives

IV and Fluid Therapy Medical Directive

- Patients with heat illness may require an IV for fluids
- Fluid bolus of 20 mL/kg is indicated if hypotensive (SBP < 90 mmHg), to a max of 2,000 mL

Seizure Medical Directive

- Patients with heat stroke may have a seizure
- Remember to check BG before administering midazolam
- Midazolam 0.1 mg/kg IV or 0.2 mg/kg IM/IN/buccal q 5 min x 2 max
- Important to remove the patient from the hot environment (the cause)!

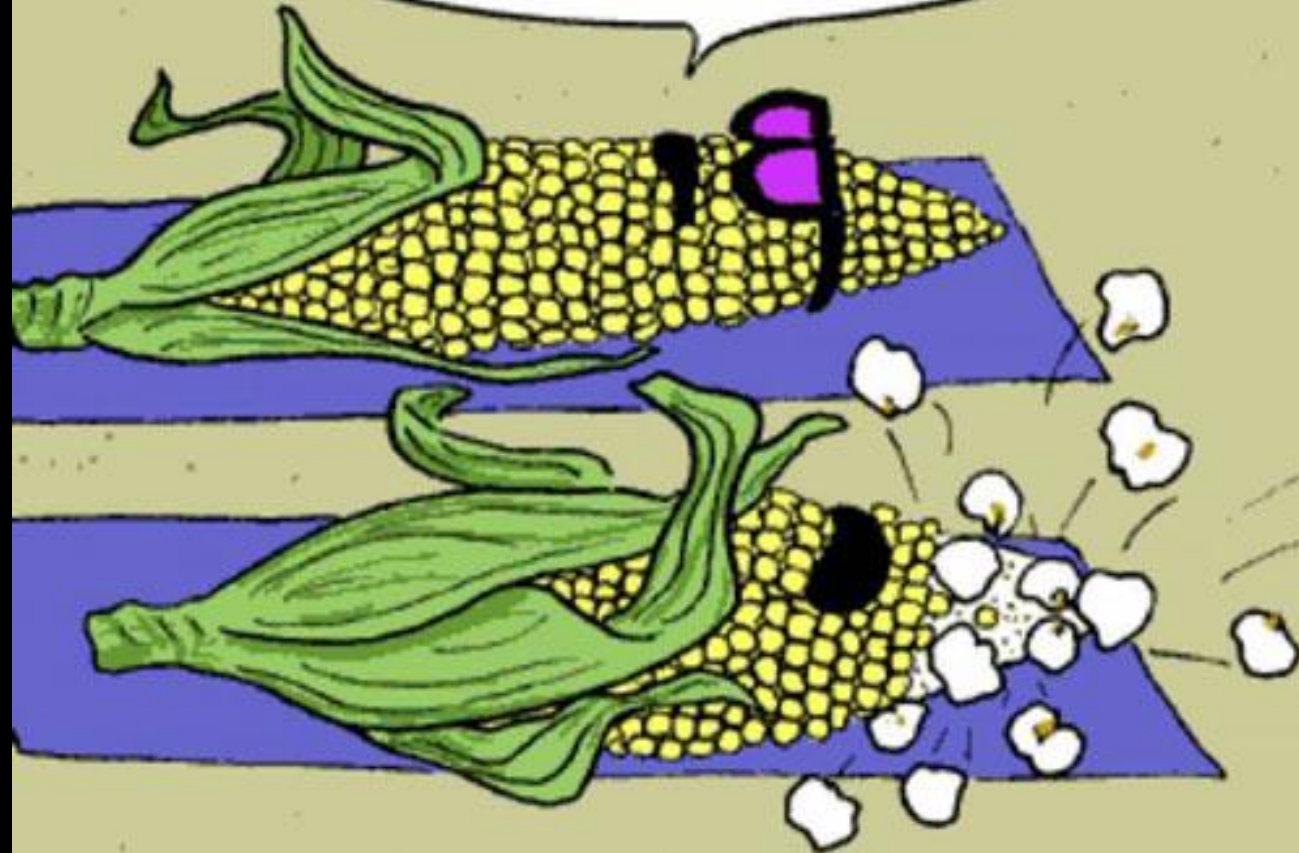
Nausea / Vomiting Medical Directive

- Patients with heat exhaustion and heat stroke may feel nauseous or vomit
- Dimenhydrinate (Gravol)
 - < 25 kg – Patch
 - 25–49.9 kg – 25 mg IV/IM
 - \geq 50 kg – 50 mg IV/IM
- Remember to dilute the dimenhydrinate if giving IV!

Combative Patient Medical Directive

- Patients with altered mental status (heat stroke) may become combative
- May give midazolam in adult patients 2.5–5 mg IV/IM q 5 min x 2 max
- Mandatory patch point if you cannot measure BP or rule out reversible causes (ie. hypoxia, hypoglycemia)

I TOLD you to wear sunscreen.



Take Home Points

- The body loses heat by conduction, convection, radiation, and evaporation
- Fever and hyperthermia are caused by different mechanisms, and treated differently
 - Fever = Antipyretics
 - Hyperthermia = Immediate rapid cooling

Take Home Points

- Minor heat illnesses: Heat cramps, edema, syncope, and rash
- Major heat illnesses: Heat exhaustion and stroke
- Neurologic dysfunction is the hallmark of heat stroke
- Immediate cooling is the cornerstone of treatment in heat stroke

Questions / Comments

References

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