Heat waves and heat stroke: Integrating planetary health into medical education through simulation

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Abstract

In a changing climate with rising temperatures, the frequency of extreme weather events, notably heat waves, is predicted to continue to increase. This upward trajectory of heat waves inevitably forecasts an increase in heat-related illnesses including heat stroke and heat exhaustion. To shed light on these trends, this project consists of the development of a simulation-based medical educational tool on heat-related illness. Grounded in the literature, this tool will educate learners on the approach to heat stroke in the emergency department (ED) and encourage further debriefing on the complications and risk factors associated with heat illness. The implementation of this simulation into medical education will encourage primary care providers (PCPs) to educate and prepare at-risk patients, in hopes of reducing the incidence of heat-related illness and subsequent ED presentations for these conditions. Ultimately, this project aims to serve as a beacon of awareness, highlighting the pressing need for proactive measures in mitigating the impact of heat-related illnesses amidst a changing climate.

Keywords

Heat stroke, Heat illness, Hyperthermia, Simulation, Planetary health

Background

Climate change has been reported as the greatest threat to human health of the 21st century[1]. Environmental exposures can impact human health in a multitude of ways. Increasing air pollution results in more respiratory illnesses, extreme weather events result in injuries and accidents, and higher temperatures result in progressing trajectories of vector-borne disease and increased rates of heat-related illnesses[2]. Considering these changes, our healthcare system and education must adapt to a higher incidence of environmental-related health impacts. An extreme heat event (EHE), also known as a heat wave, is described as a period of more than three consecutive days with a maximum daily temperature greater than or equal to 32 degrees Celsius[3]. It is anticipated that the frequency, duration, and severity of EHEs will continue to increase within the current predictions of climate change and rising temperatures[3]. There have been eight documented EHEs in Canada from 1900 to 2024, one of which is the EHE that occurred in the Halifax region in 1963[4]. In the Atlantic region of Canada, it is predicted that the annual mean surface air temperature could increase by 1.9 degrees Celsius by the end of mid-century and by 5.2 degrees Celsius by the end of the century in a high-emissions scenario[5]. These projections will inevitably lead to more EHEs and subsequently increased presentations of heat-related illness.

The spectrum of heat-related illness includes milder concerns such as heat cramps, heat rash, and heat syncope as well as the more severe heat exhaustion and heat stroke[6]. Heat stroke is defined as a core body temperature $\geq 40^{o}C$ plus central nervous system (CNS) dysfunction in the setting of exposure to environmental heat. This is in comparison to heat exhaustion which is a mild to moderate heat illness with core body temperature $< 40\ ^{o}C$ and no CNS dysfunction. Heat stroke is subdivided into two categories: exertional and non-exertional (classic) heat stroke. Exertional heat stroke (EHS) is secondary to strenuous exercise in high temperatures and typically occurs in young athletes or military personnel. Non-exertional (classic) heat stroke is secondary to passive exposure to environmental heat and typically occurs in elderly patients with chronic medical conditions during a heat wave. Additional risk factors for heat stroke include lack of acclimatization, poor physical fitness, obesity, dehydration, acute illness, anhidrosis, alcohol abuse, recreational drug use, diabetes, cardiovascular disease and certain medications[6]. The National Center for Catastrophic Sport Injury Research has reported heat-related injuries as one of the leading causes of death among high school and college athletes in the US, after trauma and cardiac causes[7]. Multiple case reports discuss the presentations and complications associated with heat stroke. A case study by Kwon et al[8] reports a case of exertional heat stroke in a 12-year-old male baseball player complicated by recurrent rhabdomyolysis. Rivera-Brown et al[9] report a case of exertional heat stroke in a 14-year-old male runner complicated by hepatic injury. Broessner et al[10] describe a case of severe exertional heat stroke with multiple organ dysfunction in a 38-year-old male hiker. Lastly, Yoshizawa et al[11] report exertional heat stroke in a 34-year-old runner complicated with rhabdomyolysis, as well as a literature review of similar presentations.

The anticipated increased trajectory of heat-related illness with increasing temperatures will undoubtedly coincide with more ED visits for these concerns. During the 2021 EHE in British Columbia (BC), there were 252 heat-related ED visits, 29.4% of which were of acute severity and 14.3% were admitted to hospital[12]. Additionally, the BC Coroners Service reported 619 deaths due to this EHE in 2021[13]. Presentations for heat-related illness to the ED are somewhat preventable visits, with proper patient preparation and risk assessment. Green et al[14] discussed the key role PCPs play in protecting at-risk patients from heat-related illness through counselling patients on their risk and prevention strategies. To encourage PCPs to initiate these conversations with at-risk patients, they must be educated on the topic of environmental health emergencies during their medical training. Okuda et al[15] completed a review on the utility of simulation to medical education and reported that it is a strong addition to enhance learners' clinical knowledge and practical skills. As such, simulation training has become an imperative part of medical education and a standard of both undergraduate and postgraduate medical curricula nationwide. On review of the literature, three published simulation cases of heat-related illness were identified. Baylis and Huang[16] developed a simulation case on exertional heat stroke in a 58-year-old male. Thouli and Stebner[17] described a simulation case of non-exertional (classic) heat stroke in an 83-year-old female. Angus et al[18] published a case of non-exertional (classic) heat stroke in a 75-year-old female. However, there is a lack of pediatric heat-related illness simulation cases identified in the literature, which is one of the main populations at risk of developing heat stroke.

This project is the first known of its kind to develop a pediatric heat stroke simulation case for use in postgraduate education for Family Medicine (FM) residents. The aim of implementing this simulation case is to both provide learners with a valuable learning experience recognizing and managing heat stroke and to consider the impacts that a changing climate will have on human health, how this will impact clinical presentations, and how we can act preemptively to advise patients on the risks and preventative strategies.

Study Design

An initial literature review was conducted to determine the current state of heat illness in Canada by evaluating recent studies describing the impact of heat waves on rates of ED visits and the outcome of heat-related illness presentations. The literature review was conducted by inputting keywords such as heat stroke, heat illness, Canada, and emergency department into Google Scholar and PubMed search engines.

Subsequently, this study consisted of the development of a pediatric heat stroke simulation case with a target audience of postgraduate FM residents. Targeting this audience will not only educate incoming PCPs on the appropriate management of heat stroke in the emergency department and rural settings but also provide them with the opportunity to reflect on how the changing climate will impact their clinical practice. Although the target audience is postgraduate FM learners, additional learners stand to benefit from participating in this case including senior undergraduate medical students and postgraduate Pediatric and Emergency Medicine residents. A simulation case was selected as the medical education tool in hopes of bridging the gap between the theory of planetary health and the practical implementation of this knowledge in a controlled simulated setting. Current published heat-related illness simulations were identified by searching the keywords heat stroke, heat illness, emergency department, simulation, and medical education in the Google Scholar search engine and on the EM Sim Cases website.

The simulation case was developed using the comprehensive and peer-reviewed template from EM Sim Cases[19]. Furthermore, the goals and objectives of the case were created based on the SMART principles and the case design followed the standard approach of pre-brief, scenario, and debrief[20]. The content of the simulation case was developed through a review of the literature using the keywords heat stroke, pediatric, heat illness, emergency department and case study in the Google Scholar search engine. This literature review yielded multiple case studies and journal articles for reference during the content development of the simulation case. Additionally, bloodwork results were determined from a review of the published case studies and comparisons to normal lab ranges for the patient's sex and age reported by the American College of Clinical Pharmacy[21]. The debrief was developed using the peer-reviewed PEARLS debriefing framework by structuring the debrief around the learning objectives of the case[22].

Results

As per standard practice in medical simulation, it is essential to begin the simulation with a pre-brief[20]. This includes an appropriate introduction and orientation to the simulation space. Additionally, it is important to address the simulation bay as a safe learning space for all and allow appropriate opportunities for learners to make mistakes, ask questions, and learn together. Lastly, the team lead for the scenario is identified, and team members' roles are assigned.

The priority educational goals and objectives of the simulation case are depicted in Table 1. These goals and objectives are used for the facilitator's overview and later as a template for discussion points during the debrief.

Table 1: Simulation Goals and Objectives

Educational Goal:	The aim of this case is for learners to determine the differential of a "hot and altered" patient, identify the diagnosis of heat stroke, initiate management prioritizing stabilization and rapid cooling, and investigate and treat complications appropriately.
Learning Objectives:	1. Demonstrate an approach to the initial assessment and management of a pediatric patient presenting with altered mental status, prioritizing the primary survey. 2. Appropriately address parental/caregiver concerns in a pediatric presentation. 3. Develop an appropriate differential for a "hot and altered" patient and determine the most likely diagnosis as heat stroke. 4. Identify the difference between exertional and non-exertional (classic) heat stroke and differentiate these from heat exhaustion. 5. Recognize the common risk factors of heat stroke. 6. Initiate rapid cooling in a patient presenting with heat stroke. 7. In a patient presenting with heat stroke, avoid the use of antipyretics and suppress shivering. 8. Order appropriate investigations to confirm the diagnosis of heat stroke and evaluate for any end-organ damage. 9. Recognize the impact of a changing climate on clinical presentations.

To begin the simulation, the facilitator provides the initial case presentation to the learners as outlined in Table 2. The case describes a 15-year-old male brought to the ED via an ambulance following a syncopal episode at a soccer game. The patient presents hyperthermic, hypotensive, tachycardic, tachypneic and with altered mental status. His GCS on arrival is 11.

Table 2: Simulation Presenting Information

Patient Name: Alex Thompson			**Age:**15	**Gender:** M	**Weight:** 54kg
Presenting Complaint: Syncope					
Temp: 39.5 ºC (axillary) 40.5 ºC (rectal) *ONLY given if asked for*	**HR:** 147	**BP:** 94/62	**RR:** 28	**O_2Sat:**97%	**FiO_2:**RA
Cap glucose: 4.1			**GCS:** 11 (E3 V3 M5)		
Triage note: In via ambulance. Collapsed on the field during a soccer game. Responsive immediately after but drowsy.					

Allergies: Nil	
Past Medical History: ADHD Distal radial fracture age 10	**Current Medications:** Adderall 20mg daily

The patient was brought to the emergency department with his mother via an ambulance. His mother is initially quite distraught but settles with appropriate consoling and provides further history about the patient. He is a competitive soccer player and they were in the middle of an outdoor soccer competition when suddenly he collapsed on the field and lost consciousness. He has a history of ADHD and his only medication is Adderall. There are no other pertinent findings on history, past medical history or social history. His only positive findings on the physical exam include abnormal vital signs, diaphoresis and muscle flaccidity.

The anticipated scenario progression, including expected and critical learner actions, is summarized in Table 3. Scenario progression includes a baseline status, minimal initial response, decline to hypoxia and seizures, stabilization and disposition. While obtaining the history, the learners should simultaneously initiate a primary survey of the patient, including obtaining two large bore IVs and placing the patient on the monitors. The team should quickly recognize that the patient is unstable, initiate an IV fluid bolus, and have the crash cart nearby. Hyperthermia should be recognized, and the team should ideally obtain a more accurate temperature using a rectal probe. Once hyperthermia is confirmed, the team should discuss the differential for a "hot and altered" patient and order appropriate investigations, including an electrocardiogram, chest x-ray, bloodwork, urinalysis and toxicology screen to identify the cause. His chest x-ray is normal and the electrocardiogram reveals sinus tachycardia. The urinalysis and urine drug screen are negative. Pertinent findings on his bloodwork reveal lactic acidosis, leukocytosis, thrombocytosis, and renal impairment. The etiology of the patient's presentation is EHS, and the appropriate initial management is rapid cooling and core body temperature monitoring. Once rapid cooling is initiated, the patient will begin to shiver which will be suppressed with the administration of a benzodiazepine. The patient's oxygen saturation will begin to drop and the team should respond accordingly by starting supplemental oxygen. Concurrently, the team should begin discussing the potential complications of heat stroke and order any further investigations to rule out end-organ damage including liver function tests, creatine kinase (CK), and coagulation studies. The only pertinent finding from these investigations is a mild elevation in CK. Shortly after, the patient will begin to seize as a complication of the heat stroke. The team should respond rapidly, and the seizure will cease after the second dose of a benzodiazepine. The team should be sure to recheck a point of care glucose during the seizure, identify hypoglycemia, and treat accordingly with dextrose. Once the seizure ceases, the patient will remain postictal with stabilized vitals. At this point in the case, the team should discuss securing the airway and ensure appropriate disposition by consulting the pediatric intensive care unit (PICU). Handover to the consulting service triggers the end of the simulation case.

Table 3: Simulation Critical Actions and Scenario Progression

Scenario State	**Expected Learner Actions**	**Triggers to Move to Next State**
1. Baseline State	• Primary assessment • IV x2 and Monitors • Parent consoled • Focused history and physical exam • Identify hyperthermia IV fluid bolus	• Hyperthermia identified
2. Initial Workup	• Rapid cooling initiated • Remove equipment/clothing • Initiate core body temperature monitoring • No antipyretics • ECG	• "Hot and altered" differential discussed, and appropriate investigations ordered • Rapid cooling initiated

	• CXR • UA, urine tox screen • BW (CBC, electrolytes, extended lytes, Cr/BUN, TSH, VBG, blood cultures, EtOH, ASA, Acetaminophen)	
3. Minimal Response & Hypoxia	• Rapid cooling • Insert foley to monitor UO • Benzos to suppress shivering • Oxygen applied via NP • Investigate for evidence of end-organ damage (LFTs, CK, INR, PTT, fibrinogen)	• Supplemental oxygen administered
4. Decline & Seizure	• Rapid cooling • Benzos administered • Recheck POC glucose • 1 amp D50 IV • Patient placed in recovery position once seizing ceases • Reassess primary survey	• Benzos administered • Primary survey reassessed
5. Stabilization & Resolution	• Patient stabilized • Rapid cooling • Consult PICU	• Discuss need for secure airway • Handover to PICU to end case

Once the simulation case has ended, a debrief will be conducted by the facilitator using the PEARLS debriefing framework. The approach of this debriefing framework is to ascertain the learners' perspectives and feelings on the case, have a learner summarize the key events, hold a facilitated discussion surrounding the learning objectives, and lastly summarize the learning points and take-home messages[22]. To aid the facilitated discussion, the case objectives (Table 1) are listed with questions to ask the learners and additional discussion points associated with each objective. The debrief is concluded once all learners' questions and concerns are appropriately addressed. Further supplementary resources on heat-related illness are included at the end of the case to be shared with learners following the completion of the simulation.

Discussion

Throughout this simulation case, there are a variety of expected and critical actions for the progression of the scenario, as depicted in Table 3. These actions depict the high yield learning points that learners should acquire from participating in this case. These learning points are summarized in the objectives outlined in the debriefing discussion. Following the completion of any simulation case, it is standard practice to allow time for a debriefing session. Debriefing is a crucial part of simulation where the main goals and objectives of the case are addressed. The debrief should typically last twice as long as the case itself[20]. The PEARLS debriefing framework is provided at the end of the case for facilitators to ensure that a structured debrief occurs after the simulation. The PEARLS debrief is a peer-reviewed framework that prioritizes learner self-assessment, feedback, teaching, and facilitated discussions focused on the learning objectives of the case[22]. This approach allows learners ample time to self-reflect and critically consider the case. Furthermore, using the case objectives for facilitated discussion ensures that all objectives are addressed, and learners can consolidate their knowledge.

The objectives of this case depict the overarching learning goals, including definitions, approach, management, risk factors, complications and the differential of heat stroke. In this case, learners must quickly recognize that the patient is unstable and in shock, which requires prioritization of the primary survey and stabilization. On presentation to the ED, the patient is hyperthermic, hypotensive, tachycardic, and tachypneic with altered mental status. These initial vital signs are similar to case studies of adolescent male patients presenting with severe EHS[8,9]. Notably, on presentation, the patient's axillary temperature is 39.5°C. This temperature correlates with a rectal temperature of 40.5°C which is only given to the learners if requested. This is a crucial learning point for learners to identify temperature variations based on probe type and the difference between a fever versus hyperthermia. Rectal temperature is the preferred method for measuring core body temperature as it is reliable and the most accurate[6]. Axillary temperatures have been reported to be a fair estimate of approximately 1°C lower than rectal temperatures in patients older than one month[23]. A fever is defined as an increase in the hypothalamic set-point due to cytokine activation, versus in hyperthermia, the hypothalamic set-point remains the same while the body's core temperature rises due to errors in thermoregulation. Thermoregulation failure may be due to endogenous heat production (ie. thyroid storm) or exogenous heat exposure (ie. heat stroke)[24]. Depending on the resource, a fever is generally described as ≥ 38 °C versus in hyperthermia, the core body temperature is ≥ 40°C. The recognition of hyperthermia in this simulation may help indicate a diagnosis of heat stroke. However, there remains a broad differential for the "hot and altered" patient and learners must rule out other causes of hyperthermia and altered mental status. This differential includes sepsis, thyroid storm, CNS causes (ie. infection, hemorrhage, stroke, status epilepticus), heat stroke, and various toxidromes. Foohey[25] developed a thorough infographic (Figure 4) depicting this differential, along with the key features and initial treatment of each etiology. Given the history of exercise in extreme heat and a normal workup for other causes, it can be identified that this patient is presenting with EHS. Additional risk factors the patient demonstrates include young age, being an athlete, and taking a stimulant for ADHD. Stimulants are a commonly prescribed medication that increases patients' risk of heat stroke and given the increasing rates of stimulant prescriptions, providers must be aware of this associated risk[26]. Furthermore, various other medications will increase patients' risk of heatstroke, such as medications commonly prescribed for hypertension, heart failure, and mental health disorders, as depicted in Figure 7[6].

The management of heat stroke, including rapid cooling and continuous monitoring of core body temperature, are further learning objectives of this scenario. Rublee et al[27] outline an evidence-based approach to the emergency management of heat stroke (Figure 5), which should be provided to learners to consolidate their learning and for future reference. There are various modalities to implement rapid cooling, including evaporative cooling, cold/ice water immersion, cooling blankets, and ice packs, which should be discussed with learners. Cold or ice water immersion is the first-line treatment modality as it has been reported as the most rapid and effective form of rapid cooling[6,27]. The steps for in-hospital cold water immersion are outlined in Figure 6[6]. If cold water immersion is not feasible, evaporative cooling may be used with wet towels and fans to cool with conductive and evaporative techniques[6]. While completing rapid cooling, core body temperature should be monitored using a rectal, esophageal, or bladder probe. Cooling is continued until a target core temperature of 38.3 – 38.8°C is reached to avoid overshooting[6]. During the simulation scenario, if rapid cooling is initiated the patient will begin to shiver. Learners must recognize that shivering during rapid cooling should be suppressed using benzodiazepines or opiates to avoid further heat generation[6]. Hyperthermia in heat stroke is not associated with a change in the hypothalamic set-point and thus antipyretics will be ineffective at reducing core body temperature. Furthermore, antipyretics such as NSAIDs and Acetaminophen can worsen potential complications of heat stroke, such as renal and hepatic injury[6].

Multiple complications can arise following heat stroke and learners should consider them during the debriefing. Potential complications include electrolyte and metabolic abnormalities, seizure, respiratory failure, rhabdomyolysis, renal injury, hepatic injury, disseminated intravascular coagulation, intestinal ischemia, cardiac dysfunction, and neurologic injury[6]. In the simulation case, the patient begins seizing as a complication, which will cease with appropriate treatment. Learners must remember to check a point of care glucose when this occurs, which will demonstrate hypoglycemia as a contributing factor. On investigations for end-organ damage secondary to heatstroke, the patient has evidence of renal injury and a mildly elevated CK. This indicates that although the patient does not currently have rhabdomyolysis, there is a likely chance that this will develop. This is consistent with findings in multiple case studies, where rhabdomyolysis as a complication of heat stroke often does not have a peak of CK until days 1 – 5 during hospital admission[8,10,11]. Renal failure is a common complication of EHS, and elevations in creatinine and blood urea nitrogen (BUN) have been seen in multiple case studies[8,10,11]. Facilitated discussion of these aspects of heat stroke following the simulation will help consolidate learners' knowledge and address any gaps identified.

In comparison to published heat-related illness simulations, this is the first known pediatric exertional heat stroke case. PCPs, who are the target audience for this simulation case, see a wide variety of clinical presentations in various clinical settings, including clinics, inpatient units, and emergency departments. Arguably, PCPs will be the first to experience changes in clinical presentations with changing temperatures. Implementation of this simulation case into postgraduate FM residency curricula will provide invaluable knowledge of a topic frequently omitted from the curriculum and initiate the discussion of how clinical presentations will differ in a changing environment. Additionally, completing a simulation related to an environmental emergency will help to bridge the gap between the theory of planetary health and practical implementation such that environmental emergencies remain a part of PCPs' differential diagnosis. Preventative strategies are the key to reducing heat-related illness presentations to clinics and EDs. PCPs are the backbone of preventative healthcare, and implementation of this simulation into FM curricula will encourage providers to discuss the prevention of heat-related illness with patients at risk. Future research for evaluating the utility of this medical simulation could be implemented by performing pre and post-simulation surveys on learners who participate in this simulation. This would aid in confirming knowledge gained and future implications to learners' practice. This study encourages further development of additional medical simulation cases addressing environmental emergencies that we anticipate increasing rates of amidst a changing climate.

Strengths and Limitations

There are a multitude of strengths to this study. This simulation case is the first known of its kind to address a case of EHS in a pediatric patient. This simulation case can be practically and readily implemented into any FM residency curriculum to address a knowledge gap and advocate for further education on environmental health emergencies. Additionally, implementing this project into the curriculum is a direct way of advocating for PCPs to counsel patients at risk for heat-related illness and sequelae. Limitations of this study include that adding this to an already full FM curriculum may be challenging and some FM residency programs may lack the appropriate resources and providers for implementation.

Conclusion

Current climate trends depict a clear prediction of increased frequency of extreme weather events, including heat waves. As PCPs, we must be prepared to address the health sequelae of these extreme weather events. This study presents a novel pediatric exertional heat stroke simulation case designed to be integrated into FM residency curricula. This simulation case was developed using peer-reviewed simulation development tools, and a literature review of journal articles, simulation scenarios and case reports. The implementation of this simulation will allow FM residents to develop an approach to the management and complications of heat stroke while simultaneously gaining perspective on the impact that a changing climate will have on clinical presentations. This study will encourage PCPs to educate and prepare at-risk patients to reduce the incidence and subsequent ED presentations of heat-related illness. Amidst a changing climate, the mitigation of heat-related illness through heightened awareness and training described in this study should be a priority of medical education. Furthermore, enhancing medical education through planetary health simulations will ensure PCPs deliver informed patient care, preparing them with the skills necessary to address the most pressing health threats of the 21st century.

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Appendix 1: Pediatric Exertional Heat Stroke Simulation Case

Section 1: Case Summary

Scenario Title:	**Pediatric Exertional Heat Stroke**
Keywords:	Heat illness, Heat exhaustion, Heat stroke, Hyperthermia, Altered mental status
Brief Description of Case:	A 15-year-old otherwise healthy male is brought to the ED following a syncopal event during a soccer game in extreme heat. His presentation is consistent with a diagnoses of exertional heat stroke with a complication of seizures.

Goals and Objectives	
Educational Goal:	The aim of this case is for learners to determine the differential of a "hot and altered" patient, identify the diagnosis of heat stroke, initiate management prioritizing stabilization and rapid cooling, and investigate and treat complications appropriately.
Objectives: (Medical and CRM)	1. Demonstrate an approach to the initial assessment and management of a pediatric patient presenting with altered mental status, prioritizing the primary survey. 2. Appropriately address parental/caregiver concerns in a pediatric presentation. 3. Develop an appropriate differential for a "hot and altered" patient and determine the most likely diagnosis as heat stroke. 4. Identify the difference between exertional and non-exertional (classic) heat stroke and differentiate these from heat exhaustion. 5. Recognize the common risk factors of heat stroke. 6. Initiate rapid cooling in a patient presenting with heat stroke. 7. In a patient presenting with heat stroke, avoid the use of antipyretics and suppress shivering. 8. Order appropriate investigations to confirm the diagnosis of heat stroke and evaluate for any end-organ damage. 9. Recognize the impact of a changing climate on clinical presentations.

Learners, Setting and Personnel				
Target Learners:	☒ Junior Learners	☒ Senior Learners	☐ Staff	
	☒ Physicians	☒ Nurses	☐ RTs	☐ Inter-professional
	☐ Other Learners:			
Location:	☒ Sim Lab	☐ In Situ	☐ Other:	
Recommended Number of Facilitators:	Instructors: 2			
	Sim Actors: 1			
	Sim Techs: 1			

Scenario Development	
Date of Development:	January 2025
Scenario Developer(s):	Ashlyn Kopanski
Affiliations/Institutions(s):	Dalhousie Family Medicine
Contact E-mail:	
Last Revision Date:	
Revised By:	
Version Number:	

Section 2A: Initial Patient Information

A. Patient Chart					
Patient Name: Alex Thompson			Age: 15	Gender: M	Weight: 54 kg
Presenting Complaint: Syncope					
Temp: 39.5 ^{o}C (axillary) 40.5 ^{o}C (rectal) *ONLY given if asked for*	HR: 147	BP: 94/62	RR: 28	O_2Sat: 97%	FiO_2: RA
Cap glucose: 4.1			GCS: 11 (E3 V3 M5)		
Triage note: In via ambulance. Collapsed on the field during a soccer game. Responsive immediately after but drowsy.					
Allergies: Nil					
Past Medical History: ADHD Distal radial fracture age 10			Current Medications: Adderall 20mg daily		

Section 2B: Extra Patient Information

A. Further History
Alex's mother (Josie) is present and will provide further history. Alex has been feeling well and acting like himself before the episode today. He has not had a fever and has been eating and drinking well. No sick contacts. No rashes. No recent travel. No "flu-like" or constitutional symptoms. Not complaining of any pain. There was no jerking movement or seizure activity movements seen. No bowel or bladder incontinence. He is a competitive soccer player who plays soccer 6 times per week. They were in the middle of a soccer competition, playing their second match of the day when suddenly he "passed out". It is a significantly hot day, and it is the second day in a row of average temperatures greater than 32^{o}C.

No prior syncopal events. No history of seizures. He has a history of ADHD but is otherwise healthy. His only medication is Adderall. His mother is sure he only took 1 pill this morning. Born at term via SVD, no complications and no NICU stay. No known alcohol or substance use. No family history of sudden cardiac death.

B. Physical Exam	
Cardio: Tachycardic. Normal S1S2 with no extra heart sounds or murmurs.	Neuro: Lethargic. Rouses to voice. Withdraws all 4 extremities to pain. Pupils 3mm, equal and reactive. GCS 12. Normoreflexic.
Resp: Tachypneic. Good air entry bilaterally. No adventitious lung sounds.	Head & Neck: Unremarkable. No tongue biting.
Abdo: Soft, non-tender.	MSK/skin: Diaphoretic, hot to touch. No rashes seen. Muscles flaccid.
Other: Normal capillary refill.	

Section 3: Technical Requirements/Room Vision

A. Patient
☒ Mannequin *(adolescent child)*
☒ Standardized Patient *(patient's mother)*
☐ Task Trainer
☐ Hybrid
B. Special Equipment Required
Cooling aides: cold/ice water immersion, evaporative cooling with wet towels and fans, ice packs, etc. Crash cart including airway equipment
C. Required Medications
IVF (NS or RL) Benzodiazepines (Lorazepam or Midazolam) D50
D. Moulage
N/A
E. Monitors at Case Onset
☐ Patient on monitor with vitals displayed
☒ Patient not yet on monitor

F. Patient Reactions and Exam
Relevant physical exam findings that require mannequin programming or cues from patient. A – Normal. B – Tachypneic. Normal breath sounds. C – Tachycardic and hypotensive. D – Saying inappropriate words. Opens eyes to voice. Localizes pain in all four extremities. E – Skin is diaphoretic and warm.

Section 4: Sim Actor and Standardized Patients

Sim Actor and Standardized Patient Roles and Scripts	
Josie Thompson (Alex's mother)	Initial behaviour is very upset, concerned and worried about her son. Potential initial statements include: "What is happening to him?" "Is he going to be okay?" "Please help him!" "Why is he acting like this!" Appropriately calms once team addresses her concerns. Further history provided when directly asked as outlined above. If team is not identifying the cause as heat illness after an appropriate amount of time (ie 7-10 minutes): will prompt team with statements including "It was so hot during his game" and subsequently "Is this from the heat?"

Section 5: Scenario Progression

Scenario States, Modifiers and Triggers				
Patient State/Vitals	Patient Status	Learner Actions, Modifiers & Triggers to Move to Next State		Facilitator Notes
1. Baseline State Rhythm: sinus tachy HR: 147 BP: 94/62 RR: 28 O_2SAT: 97% RA T: 39.5 ºC axillary 40.5ºC rectal (*ONLY given if asked for*) GCS: 11 (E3V3M5)	Patient is altered. Eyes open to voice, saying inappropriate words, localizes to pain. Skin is warm and diaphoretic.	<u>Expected Learner Actions</u> ☐ Primary assessment ☐ IV x2 and Monitors ☐ Parent consoled ☐ Focused history and physical exam ☐ Identify hyperthermia ☐ IV fluid bolus	<u>Modifiers</u> *Changes to patient condition based on learner action* - Hypotension and tachycardia respond somewhat to IV fluids <u>Triggers</u> *For progression to next state* - Hyperthermia identified	Residents should apply pads and connect to lifepack. Residents should recognize hyperthermia and altered mental status.
2. Initial Workup Rhythm: sinus tachy HR: 125 BP: 105/70 RR: 28 O_2SAT: 97% RA T: 40.5ºC rectal GCS: 11 (E3V3M5)	Remains altered.	<u>Expected Learner Actions</u> ☐ Rapid cooling initiated ☐ Remove equipment/clothing ☐ Initiate core body temperature monitoring ☐ NO antipyretics ☐ ECG ☐ CXR ☐ UA, urine tox screen ☐ BW (CBC, lytes, extended lytes, Cr/BUN, TSH, VBG, blood cultures, EtOH, ASA, Acetaminophen)	<u>Modifiers</u> - Temperature decreases to 40.2ºC (if cooling initiated) <u>Triggers</u> - "Hot and altered" differential discussed, and appropriate investigations ordered - Rapid cooling initiated	Rapid cooling options include cold/ice water immersion, evaporative cooling, ice packs, etc. Residents should <u>not</u> administer antipyretics, and this would not change temp if done so. Core body temperature monitoring should be initiated using a rectal, esophageal or bladder probe. Residents may consider broad spectrum antibiotics.

3. Minimal Response Rhythm: sinus tachy HR: 115 BP: 108/72 RR: 22 O_2SAT: 91% T: 40.2ºC rectal (if cooling initiated) GCS: 11 (E3V3M5)	Remains altered. Begins to shiver IF rapid cooling has been initiated.	<u>Expected Learner Actions</u> ☐ Rapid cooling ☐ Insert foley to monitor UO ☐ Benzos to suppress shivering ☐ Oxygen applied via NP ☐ Investigate for evidence of end-organ damage (LFTs, CK, INR, PTT, fibrinogen)	<u>Modifiers</u> - O2 sats increase to 95% with NP at 2L <u>Triggers</u> - Supplemental oxygen administered	Rapid cooling is continued until a target core temperature of 38.3 – 38.8ºC to avoid overshooting. Shivering is suppressed to avoid further heat generation.
4. Decline Rhythm: sinus tachy HR: 125 BP: 108/72 RR: 22 O_2SAT: 95% on 2L NP T: 39.9ºC rectal (if cooling initiated) GCS: 8 (E2V2M4) *postictal* **POC Gluc: 2.6**	Starts seizing. Postictal once seizing resolves. Eyes open to pain, incomprehensible sounds, withdraws from pain.	<u>Expected Learner Actions</u> ☐ Rapid cooling ☐ Benzos administered ☐ Recheck POC glucose ☐ 1 amp D50 IV ☐ Patient placed in recovery position once seizing ceases ☐ Reassess primary survey	<u>Modifiers</u> - Seizing resolves with second dose of benzo - POC Glucose increases to 3.8 post D50 <u>Triggers</u> - Benzo administered - Primary survey reassessed - Discuss need for secure airway	
5. Resolution Rhythm: sinus tachy HR: 109 BP: 100/70 RR: 22 O_2SAT: 95% on 2L NP T: 39.9ºC rectal (if cooling initiated)	Postictal.	<u>Expected Learner Actions</u> ☐ Patient stabilized ☐ Rapid cooling ☐ Consult PICU	<u>Modifiers</u> <u>Triggers</u> - Handover to PICU to end case	

GCS: 8 (E2V2M4) *postictal*				

Section 6: Laboratory Results

CBC WBC – **11.12** Hgb – 140 Plt – **460** Lytes Na – 140 K – 4.3 Cl – 107 Urea – **10.5** Cr – **124** Glucose – 4.1 Ca – 2.42 Mg – 0.87 PO_4 – 1.36 CK – **893** TSH – normal VBG pH – **7.29** pCO_2 – **28** pO_2 – 35 HCO_3 – **15** Lactate – **8.1**	Cardiac/Coags INR – 1.0 aPTT – 24 Biliary AST – 40 ALT – 30 Tox EtOH – 0 ASA – 0 Tylenol – 0 Urine UA – negative UDS – negative

Section 7: ECGs, X-rays, Ultrasounds and Pictures

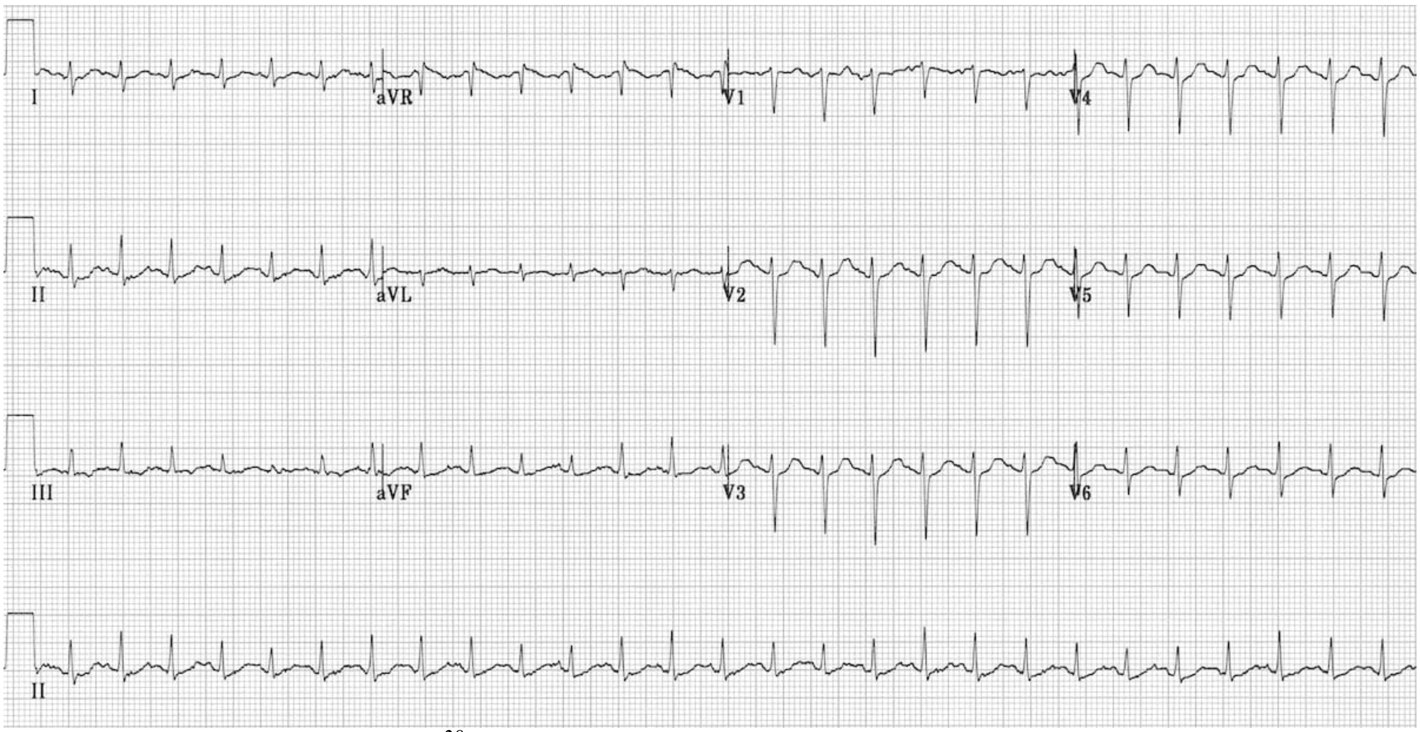

Figure 1: ECG Sinus Tachycardia[28]

Figure 2:Normal Pediatric CXR[29]

Section 8: Facilitator Cheat Sheet & Debriefing Tips

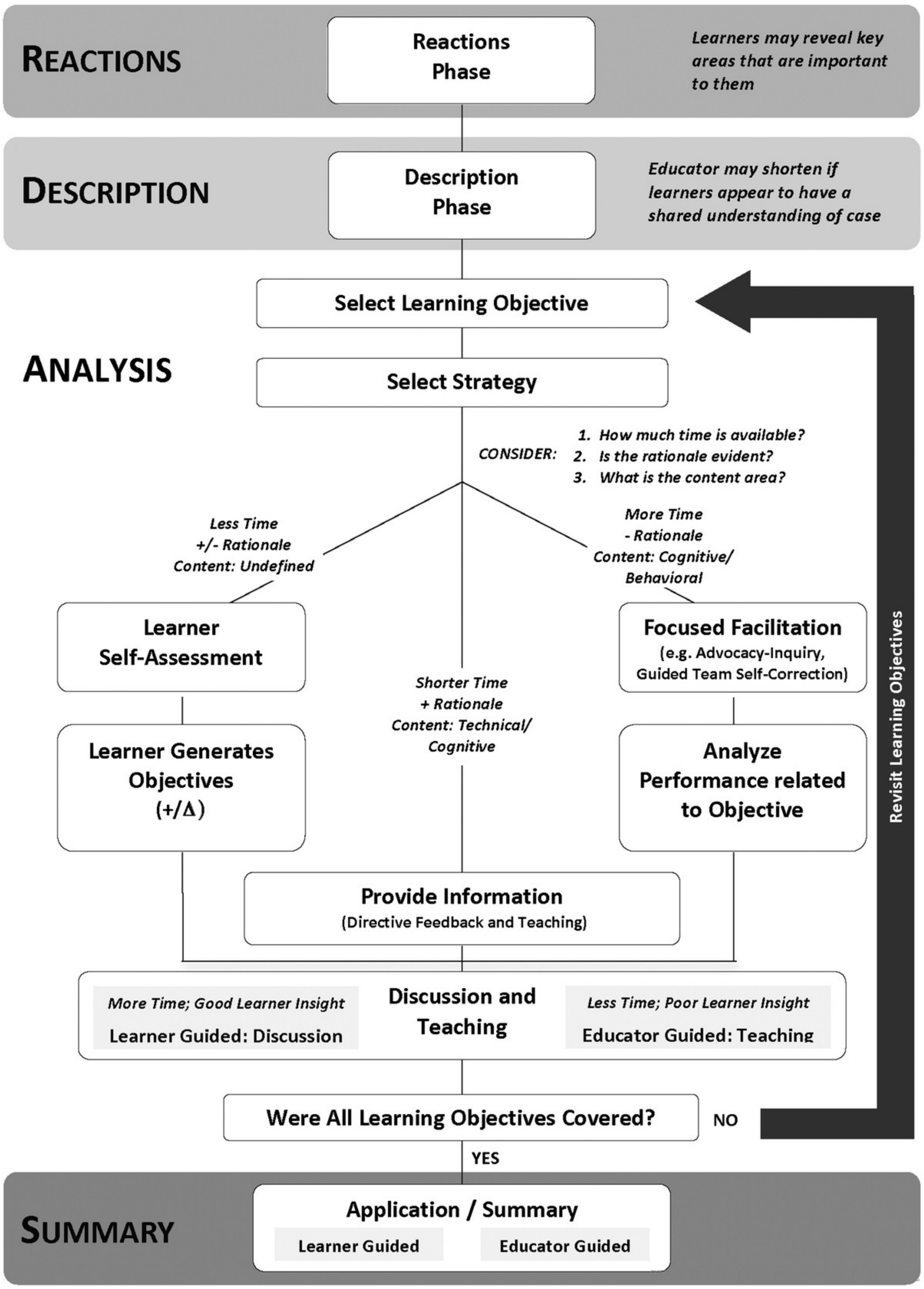

Figure 3: PEARLS Debriefing Framework[22]

Linking Objectives to the Debrief:

1. Demonstrate an approach to the initial assessment and management of a pediatric patient presenting with altered mental status, prioritizing the primary survey.
   How did this go during the simulation? What was your initial impression and approach?

2. Appropriately address parental/caregiver concerns in a pediatric presentation.
   How do you manage addressing a high acuity case while simultaneously attending to concerned family members?

3. Develop an appropriate differential for a "hot and altered" patient and determine the most likely diagnosis as heat stroke.
   Differential for a "hot and altered" patient includes sepsis, thyroid storm, CNS causes (infection, ICH, stroke, status epilepticus), heat stroke, and various toxidromes (Figure 4).
   How did the team come to the most likely diagnosis of heat stroke?

4. Identify the difference between exertional and non-exertional (classic) heat stroke and differentiate these from heat exhaustion.
   Heat stroke = core body temperature ≥ 40°C plus CNS dysfunction in the setting of environmental heat.
   Exertional heat stroke = heat stroke secondary to strenuous exercise in high temperatures. Typically occurs in young athletes or military personnel.
   Non-exertional heat stroke = heat stroke secondary to passive exposure to environmental heat. Typically occurs in elderly with chronic medical conditions during a heat wave.
   Heat exhaustion = core body temperature < 40°C and ***no*** *CNS dysfunction; mild to moderate heat illness due to exposure to or strenuous exercise in high temperatures.*

5. Recognize the common risk factors of heat stroke.
   Risk factors include extremes of age, lack of acclimatization, poor physical fitness, obesity, dehydration, acute illness, anhidrosis, alcohol abuse, recreational drug use, diabetes, cardiovascular disease and certain medications (Figure 7).
   How can you apply knowledge of these risk factors to your clinical practice?

6. Initiate rapid cooling in a patient presenting with heat stroke.
   Discuss the initial management approach to heat stroke including rapid cooling. Rapid cooling options include evaporative cooling, cold/ice water immersion, cooling blankets, and ice packs.
   Core body temperature should be monitored using a rectal, esophageal, or bladder probe and cooling is continued until a target core temperature of 38.3 – 38.8°C to avoid overshooting. (Figure 5).

7. In a patient presenting with heat stroke, avoid the use of antipyretics and suppress shivering.
   Consider a discussion of the following:
   Antipyretics (NSAIDs and Acetaminophen) should not be administered as hyperthermia in heat stroke is not associated with a change in the hypothalamic set-point and antipyretics can worsen potential complications (renal injury, hepatic injury, DIC).
   Shivering should be suppressed using benzodiazepines to avoid further heat generation.

8. Order appropriate investigations to confirm the diagnosis of heat stroke and evaluate for any end-organ damage.
   Discuss the potential complications of heat stroke including electrolyte and metabolic abnormalities, seizure, respiratory failure, rhabdomyolysis, renal injury, hepatic injury, DIC, intestinal ischemia, cardiac dysfunction, neurologic injury, etc).
   Appropriate initial investigations include CBC, electrolytes, extended lytes, renal function, urinalysis, CK, LFTs, VBG, lactate and INR/PTT. Consider tox screen (UDS, EtOH, ASA, Acetaminophen).

9. Recognize the impact of a changing climate on clinical presentations.
   What other presentations may we see more frequently in clinics/EDs with the changing climate? Have you had any experience with environmental health presentations (ie. heat/cold-related, respiratory exacerbations, vector-borne illnesses, etc)?

The Hot and Altered Patient in the ED

- **Think beyond sepsis!** There is a huge DDx for altered patients with elevated body temperature: be thoughtful, take your time, and avoid anchoring.
- **These patients can be very sick**. Be prepared to resuscitate, manage seizures, intubation, call for help, etc.

1) Assess & Resuscitate

- ABCs
- IV x 2, Monitors
- Apply oxygen
- Fluids
- Benzos PRN for: shivering, agitation, seizures
- Antipyretics if fever
- Initiate cooling if hyperthermia

2) Determine Cause

- **Hx:** New meds, drugs, associated symptoms?
- **Px:** thorough neuro (clonus or rigid?), skin, pupils
- **Bedside Tests:** POC Glucose, ECG
- **Labs:** CBC, Lytes, Cr, BUN, Liver enzymes, CK, Coags, Salicylate levels, Acetaminophen level, Alcohol level, VBG, ± Lithium level, Blood cultures
- **Urine:** Urinalysis, Urine culture, Urine Drug Screen
- **Imaging:** CT head

Heat Stroke

- High body temp + **CNS dysfunction**

Exertional Heat Stroke
- T>40° after Strenuous activity
- Typically young athletes, hot days

Classic Heat Stroke
- People with impaired thermoregulation or who are unable to cool themselves (ex: can't get out of hot environment or drink)
- Ex: elderly, children, substance use, psychiatric comorbidities, etc.

Clin Pres
- Weakness, nausea, lethargy, dizzy
- CNS: disoriented, irritable, ataxia, emotional, confused, Sz, coma
- Tachycardia, Hypotension
- Dry mouth, Thirst, Sweating
- Nausea, vomiting

Tmt
- Rapid Cooling!
- Evaporative: spray with water, fan
- Ice packs to axilla & groin
- Benzos to reduce shivering, agitation

Heat stroke is distinguished from heat exhaustion by +CNS impairment

Infections

- Sepsis
- Encephalitis, Meningitis, Abscess

Neuro Pathology

- ICH
- Stroke
- Status Epilepticus

Thyroid Storm

- Hx of Hyperthyroidism
- Precipitating event: infection, trauma, surgery, etc.

Clin Pres
- Altered: restless, delirium, Sz, coma
- Temp can be 40°+

Tmt
- Benzos, Fluids
- Propranolol, PTU, 1hr later: Iodine
- Hydrocortisone

Thyroid Hx + Altered + Fever

Malignant Hyperthermia

- From: Succinylcholine, inhaled anesthetics
- Onset: Mins - 24 hour

Clin Pres
- All 4 vitals UP
- Normal pupils, **Sweating** & **mottled**
- Slow reflexes
- Agitation
- **Muscle rigidity** (including Masseter)

Ix
- **High CK, High K** (with ECG findings), Metabolic Acidosis

Tmt
- Supportive
- **Dantrolene**

Clue: rapid rise in EtCO2

Neuroleptic Malignant Syndrome

- From: Dopamine antagonists (antiemetics, antipsychotics like Haloperidol)
- Onset: Days, with new or old Rx

Clin Pres
- All 4 vitals UP
- Dilated/normal pupils, **Sweating**
- **Lead pipe rigidity**, severe, global
- Can be ***slowed* neuro**: slow reflexes, mutism, staring, bradykinesia, coma

Ix
- **High CK**, 4x upper limit normal

Tmt
- Supportive
- +/- **Bromocriptine**, **Dantrolene**

FARM: Fever, Autonomic dysfunction, Rigidity, Mental status changes

Serotonin Syndrome

- From: SSRIs, TCAs, CNS stimulants, Opioids, etc.
- Onset: <12 hours

Clin Pres
- All 4 vitals UP
- **Dilated** pupils, **Sweating**
- **Clonus**, Ocular clonus, Rigidity, Tremor, **Hyperreflexia (legs > arms)**
- Agitation, seizures, coma
- Vomiting, **Diarrhea**

Tmt
- Supportive
- **Cyproheptadine**

SHIVERS: Shivering, Hyperreflexia, Increased temp, Vital sign instability, Encephalopathy, Restless, Sweating.

Sympathomimetic Toxidrome

- From: Amphetamines, cocaine etc
- Onset: <24 hours

Clin Pres
- All 4 vitals UP
- **Dilated** pupils, **Sweating**
- Tremors, hyperreflexia
- Agitation, seizures, coma

Tmt
- Supportive
- Avoid B-blockers
- If HTN post benzo: Phentolamine

Similar to Anticholinergic Toxidrome except skin is sweaty

ETOH & Sedative-Hypnotic Withdrawal

- SH: Benzodiazepines, Barbiturates
- Onset: depends on substance. Alcohol can start as early as 6hr.

Clin Pres
- Diaphoretic
- Altered, Agitated, Sz

Tmt
- Supportive
- Benzos
- EtOH: Thiamine

Consider withdrawal in any patient who presents agitated or altered

Lithium Toxicity

- Acute ingestion or chronic
- Lithium doesn't cause hyperthermia, but fever can precipitate chronic lithium toxicity

Clin Pres
- Tachycardia, HTN
- **Clonus**
- Agitation, seizures, hallucinations

Ix
- Add serum lithium levels
- Tmt: fluids, dialysis

Order lithium level for any altered patient taking lithium

Salicylate Overdose

- ASA, Bismuth Salicylate, Aminosalicylates (IBD), Wintergreen

Clin Pres
- Tachycardia, Tachypnea & **Hyperpnea** (fast+deep)
- **Tinnitus**, agitation, confusion, Sz, lethargy, coma

Ix
- Metabolic acidosis + Resp Alkalosis
- Hypokalemia, Hypoglycemia

Tmt
- Fluids, HCO3, dialysis

Metabolic acidosis + Resp alkalosis

Anticholinergic Toxidrome

- From: Antihistamines, TCAs, Anti-parkinson, etc.
- Onset: <12 hours

Clin Pres
- All 4 vitals UP
- **Dilated** pupils, **Red Dry skin**
- Agitated delirium, Sz, coma

Tmt
- Consider: **Physostigmine** (Do not use if TCA overdose possible)

Hot as a hare, Blind as a bat, dry as a bone, red as a beet, mad as a hatter

Hyperthermia: body produces more heat than it dissipates.
Fever: body's temp set point elevated due to pyrogens.

Resources:
https://rebelem.com/hyperthermia-syndromes/
https://litfl.com/hyperthermia/
https://litfl.com/hyperthermia-associated-toxidromes/

@SarahFoohey

Figure 4: "Hot and Altered" Differential Infographic[25]

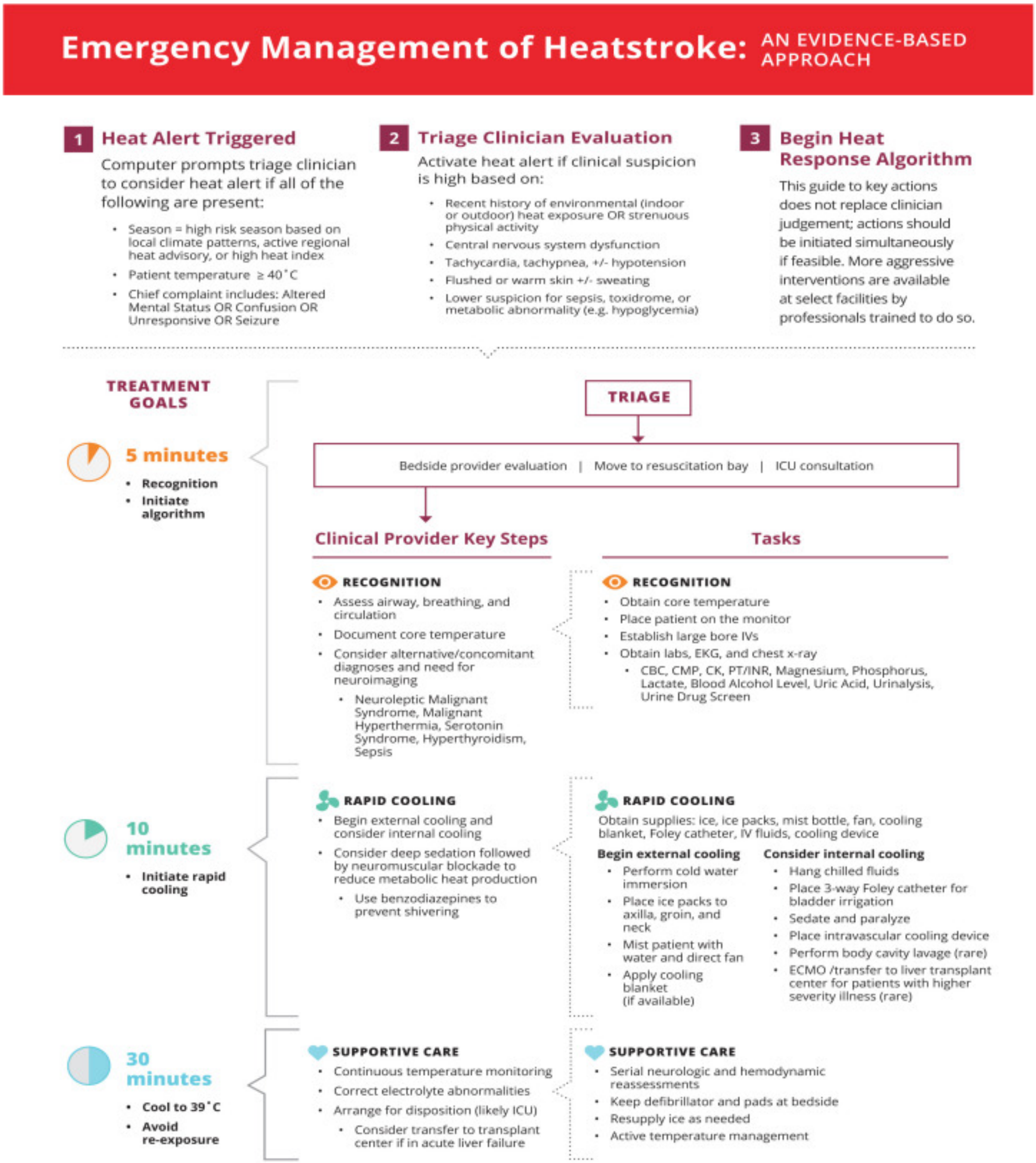

Figure 5: Evidence-Based Approach to the Management of Heat Stroke[27]

Table 4. Steps for hospital-based ice-water immersion.

1. Prepare a disposable body bag on a gurney with five buckets of ice.
2. Transfer patient from prehospital stretcher directly into the pouch, apply monitors and temperature-sensing device, such as a temperature-sensing Foley catheter. Pour buckets of ice around the body, then pour tap water over the ice to the level of the midaxillary line.
3. After initial resuscitative measures are completed, the bag can be closed to the level of the patient's neck until cooled to <39 °C—this cooling should take approximately 10 min.
4. When the patient is cooled to <39 °C, transfer the patient from the bag to a dry bed, and use dry towels to remove the cold water. Zip up and discard the bag.

Figure 6: In-Hospital Ice Water Immersion[6]

Table 2 Medications and drugs that may contribute to heat illness
Alcohol
Alpha adrenergics
Amphetamines
Anticholinergics
Antihistamines
Antipsychotics
Benzodiazepines
Beta blockers
Calcium channel blockers
Clopidogrel
Cocaine
Diuretics
Laxatives
Neuroleptics
Phenothiazines
Thyroid agonists
Tricyclic antidepressants

Figure 7: Medications Associated with Risk of Heat Stroke[6]