Indications for Use: The ARCTIC SUN® Temperature Management System is a thermal regulating system, indicated for monitoring and controlling patient temperature in adult and pediatric patients of all ages.

Contraindications
There are no known contraindications for the use of a non-invasive thermoregulatory system.
Do not place ARCTICGEL™ Pads on skin that has signs of ulcerations, burns, hives or rash.
Do not remove the fabric release liner of the Neonatal ARCTICGEL™ Pad and expose the hydrogel.
Do not place ARCTICGEL™ Pads on immature (non-keratinized) skin or premature babies.
While there are no known allergies to hydrogel materials, caution should be exercised with any patient with a history of skin allergies or sensitivities.

Warnings
When using the ARCTIC SUN® Temperature Management System, note that all other thermal conductive systems, in use while warming or cooling with this device may interfere with patient temperature control.

Cautions
Due to underlying medical or physiological conditions, some patients are more susceptible to skin damage from pressure and heat or cold. Patients at risk include those with poor tissue perfusion or poor skin integrity due to edema, diabetes, peripheral vascular disease, poor nutritional status, steroid use or high dose vasopressor therapy. Examine the patient’s skin under the ARCTICGEL™ Pads.
Skin injury may occur as a cumulative result of pressure, time and temperature.
Carefully remove ARCTICGEL™ Pads from the patient’s skin at the completion of use. Aggressive removal or removal of cold pads from the patient’s skin may result in skin tears.
The rate of temperature change and potentially the final achievable patient temperature is affected by many factors. Treatment application, monitoring and results are the responsibility of the attending physician. If the patient does not reach target temperature in a reasonable time or the patient is not able to be maintained at the target temperature, the skin may be exposed to low or high water temperatures for an extended period of time which may increase the risk for skin injury.

Please consult package insert for more detailed safety information and instructions for use.
Disclosure

Product Training and Education: Any discussion regarding BARD® products during this presentation is limited to information that is consistent with BARD® labeling for these products.
Learning Objectives

Upon completion of this module, the participant will be able to:

- Recognize role of Targeted Temperature Management (TTM)
- Review TTM evidence-based practice
- Discuss patient management during TTM
  - Identifying and addressing shivering
  - Fever control
Why are we here today?
Global Ischemia

• Transient (5 – 30 minutes) complete or nearly complete lack of blood flow

• Lack of blood supply leads to ischemia

• If blood flow is not restored within 30 minutes, widespread necrosis occurs

Focal Ischemia

• Results from occlusion of a single cerebral blood vessel

• Necrosis occurs near the occluded vessel if reperfusion does not occur within 60 min

• Surrounding area (penumbra) may be salvaged if reperfusion occurs

Neuronal Damage from Ischemia

- Complex negative cascade of reactions at cellular level
- May begin minutes after injury and continue up to 72 hours or longer
- Chain of events is called secondary injury or reperfusion injury

Ischemic Cascade$^{1-3}$

- Mitochondrial dysfunction
- Release of excitatory neurotransmitter glutamate
- Excess release of calcium
- Disruption of cell membranes
- Free radical production
- Blood brain barrier dysfunction

“preventing ischemic injury is central to all neuroprotective strategies”

Targeted Temperature and Patient Management
Targeted Temperature Management (TTM)

- Prescribed TTM includes dosage and duration
- Current trends based on recent studies
  - 33°C - 36°C selected and achieved
  - 36°C
- Hyperthermia control

Key Clinical Considerations*

33º

- Inhibit neurotransmitter release¹
- Inhibit free radical production¹
- Reduce oxygen consumption¹
- Decrease cerebral metabolic rate (5 - 8% for every 1°C)¹
- Preserve blood brain barrier integrity¹
- ICP and cerebral edema are decreased²

36º

- Consider the shivering threshold: dependent on patient’s thermoregulatory set point¹,²
- Consider the reduction in cerebral metabolic demand¹
- May be appropriate for patient population that cannot tolerate 33°C³


*Follow physician orders and / or your hospital’s policies and procedures for selecting target temperature
Key Clinical Considerations

Hyperthermia

• Hyperthermia control with targeted temperature management in either the hypothermic or normothermic mode

• Occurs in 20 – 50% of critically ill neurologic patients

• Independently associated with increased morbidity and mortality

Four Phases*

- **Induction**: 32°C – 34°C, 12 – 24 hours
- **Maintenance**: 32°C – 34°C
- **Rewarm**: 0.25°C / hour
- **Normothermia**: 37°C

*Duration to follow institutional and society guidelines

Four Phases*

- Induction
- Maintenance
- Rewarm
- 72hrs Controlled Normothermia

36°C for 36hrs of Intervention

Normothermia

4+ Day Protocol

*Duration to follow institutional and society guidelines

Four Phases

- **Induction**: 37°C
- **Maintenance**: 32°C – 36°C for 24 hours
- **Rewarm**: 37°C, 0.25°C/16hrs
- **Normothermia**: 37°C

*Duration to follow institutional and society guidelines

What’s the latest news in the TTM field?

2010

Comatose adult patients with ROSC should be cooled to 32°C to 34°C for 12 to 24 hours

What’s the latest news in the TTM field?

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2015

All comatose adult patients with ROSC should have TTM...

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What’s the latest news in the TTM field?

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Comatose adult patients with ROSC should be cooled to 32°C to 34°C for 12 to 24 hours.

2015

All comatose adult patients with ROSC should have TTM, with a target temperature between 32°C and 36°C selected and achieved, then maintained constantly for 24 hours.

What’s the latest news in the TTM field?

Select and Maintain

- Specific conditions of the patient may favor selection of one temperature over another

- Allowing patients to warm above 36°C would be inconsistent with current TTM recommendations

What’s the latest news in the TTM field?

Prehospital Initiation

Routine prehospital cooling of patients after ROSC with rapid infusion of cold intravenous fluids is no longer recommended

What’s the latest news in the TTM field?

Actively Preventing Fever

- Fever has the potential of worsening ischemic injury
- Actively preventing fever in comatose patients after TTM
- The simplest method to prolonged hyperthermia prevention may be to leave the devices / strategies used for TTM in place

Physiological Effects of Therapeutic Hypothermia

Cardiovascular

- ↓ BP, HR, CO

- EKG Changes
  - Prolonged PR interval
  - Widening QRS complex
  - Increased QT wave
  - J or Osborn wave

*Representative of target temperatures 32 - 35°C

Physiological Effects of Therapeutic Hypothermia

Cardiovascular

*Representative of target temperatures 32 - 35°C

Physiological Effects of Therapeutic Hypothermia*

- **Hematological**\(^1\)
  - Impaired clotting cascade
  - Impaired platelet function: potential increase in bleeding risk
  - Decreased WBC count

- **Renal**
  - ↑ Diuresis\(^2,4\)
  - Electrolyte loss\(^3\)

- **Gastrointestinal**\(^1\)
  *Representative of target temperatures 32 - 35°C*
  - Impaired bowel function / motility

---

Physiological Effects of Therapeutic Hypothermia*

- **Systemic**
  - $\downarrow$ O$_2$ consumption and CO$_2$ production\(^1,3\)
  - Left shift on oxyhemoglobin curve: O$_2$ is not readily released to the tissues\(^4\)
  - Lactic acidosis\(^4\)

- **Endocrine\(^1,3\)**
  - $\downarrow$ Insulin secretion

- **Immune suppression\(^1\)**
  - $\uparrow$ Infection: wound infections and pneumonia

- **Other\(^1\)**
  - Shivering

*Representative of target temperatures 32 - 35°C

Shivering

- A physiological reflex mechanism that occurs when the body needs to produce or maintain heat
- The primary center for shivering is found in the posterior hypothalamus

Thresholds for Physiological Thermoregulatory Responses
Shivering

- Involuntary sympathetic response to generate heat\(^4\)
  - Vasoconstriction
  - Piloerection

- Leads to increased:\(^1-4\)
  - Metabolic rate
  - Metabolic demand
  - Oxygen consumption
  - Carbon dioxide production

---

Shivering Management

- Counter warming is the first line therapy for shivering treatment\(^1\)

- Sedation prevents increased metabolism\(^1\)

- Paralytic agents affect shivering\(^1-3\)

  Precautions: difficult to identify seizures, select agent with anticonvulsant properties, continuous EEG may be utilized, drug metabolism is affected, appropriate dosing must be tailored to the specific conditions of the patients and must be tightly monitored

Phases of Therapy

Induction Phase

- Careful monitoring of fluid balance
- Glucose control
- Monitor for hypertension
- Electrolyte management
- Prevention of shivering

General Considerations: This list may vary depending on the patient’s underlying condition.

Phases of Therapy

Maintenance Phase

- Monitor for:
  - EKG changes
  - Bleeding
  - Skin changes

- Maintain fluid status
- Infection surveillance
- Frequent electrolyte monitoring
- Avoid hyperglycemia

General Considerations: This list may vary depending on the patient’s underlying condition.

Phases of Therapy

Rewarming Phase

- Slow and controlled rewarming (0.01 – 0.5°C per hour)

- Rapid rewarming may lead to:
  - Hypoglycemia
  - Increased ICP
  - Rapid electrolyte shifts (hyperkalemia)
  - Sudden vasodilation
  - Cardiac arrest

General Considerations: This list may vary depending on the patient’s underlying condition.

Phases of Therapy

Controlled Normothermia Phase

- Fever during the first 72 hours after ROSC has been associated with poor outcome
- Many clinicians attempt to maintain normothermia (36 - 37°C) during this time for at least 72 hours after ROSC

General Considerations: This list may vary depending on the patient’s underlying condition.
Neuroprognostication

- TTM alters the ability to obtain a clinical neuro exam
- Drug clearance is decreased so sedatives may be present up to 48 - 72 hours
- Decisions regarding withdrawal of care must be delayed until adequate clinical exam can be performed
- Follow your institution’s guidelines for prognostication

Controlled Normothermia
The Hypothalamus

- Plays a key role in temperature modulation

- Set point is where the body will attempt to maintain temperature
  - This may be ‘reset’ based on stimuli
  - Fever is one example of a shift in the set point
  - Damage to this structure may result in hyperthermia

Prevalence of Hyperthermia

- Defined as temperature > 38°C
- Occurs in up to 50% of all neurologically-injured patients

What is your institution’s definition of a fever?

Fever and Brain Injury

• Fever after trauma or ischemia may exacerbate damage from the original insult\(^2\)

• Hyperthermia may worsen damage after focal and global ischemia\(^2\)

• As high as 13% ↑ in metabolic rate associated with every 1°C ↑ in body temperature\(^1\)

---

Fever and Hemorrhage

- Intraventricular hemorrhage is a strong risk factor for fever development\(^3\)

- A small amount of blood in CSF may induce fever\(^3,4\)

- Fever has been associated with cerebral vasospasm\(^1-3\)

Sources of Fever

Infectious and Non-Infectious

- Infectious
  - Pneumonia
  - Urinary Tract Infection
  - Invasive Central Lines
  - NG Tubes
  - etc.

- Non-infectious
  - Drugs, medications

Neurogenic or Central

- Fever resulting from damage to the thermoregulatory center in the hypothalamus

- Occurs in neurologically impaired patients
  - Especially those with trauma or intracranial lesions

References:
Understanding the Effects of Temperature Management
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BMD/AS50/0516/0115
UNCONTROLLED HYPERTHERMIA

Increases Metabolic Demand
Increases Risk of Cerebral Edema
Increases Length of Stay
### UNCONTROLLED HYPERTHERMIA

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Blankets / Wraps / Tylenol
UNCONTROLLED HYPERTHERMIA

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Uncontrolled Hyperthermia

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**CONTROLLED NORMOTHERMIA**

Arctic Sun® Temperature Management System

Uncontrolled Hyperthermia

Blankets / Wraps / Tylenol

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**CONTROLLED NORMOTHERMIA**

- Controlled Normothermia
- Uncontrolled Hyperthermia
- Fever is Broken

ARCTIC SUN® Temperature Management System
Blankets / Wraps / Tylenol

BMD/AS50/0516/0115
Uncontrolled Hyperthermia

Elevated body temperature independently contributes to increased length of stay in neurologic intensive care unit patients.

Michael H. Driggin, MD, FRCPC, Nancy L. Armon, MA, Queen Z. Funk, MBA, Queen S. Urban, RN, PhD

Clinical trial of a novel surface cooling system for fever control in neurocritical care patients

Stephan A. Mayer, MD; Robert G. Kowalski, BS; Mary Preciutti, RN; Nour H. Zeitbakhovitch, MS; Eunice M. Scannell, RN; Brian-Yed Fitzsimmons, MD; Difee P. W. Yee, MD; Y. Elym D. D. F. B. Pho; Andrew M. Neideck, MD; Heidi A. Jarjour, MD; Jan Casselman, MD; Kurt T. Kroter, PhD; Augusto Parra, MD; Christopher C. M. MD

Neurologic Critical Care

Impact of Fever on Outcome in Patients With Stroke and Neurologic Injury

A Comprehensive Meta-Analysis

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Elevated body temperature independently contributes to increased length of stay in neurologic intensive care unit patients

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Elevated body temperature independently contributes to increased length of stay in neurologic intensive care unit patients

The Evidence Suggests

Elevated body temperature independently contributes to increased length of stay in neurologic intensive care unit patients*
Overview of Cooling Methods

• Conventional\(^1,^3\)
  – Antipyretic drugs
  – Ice
  – Fans
  – IV saline infusions
  – Water blankets

• Advanced\(^1,^3\)
  – Non-invasive core cooling
  – Intravascular

Core Precision with Advanced Surface Cooling

ARCTICGEL™ Pads

- Targeted Temperature Management with Core Precision
- Three-layered construction
- LEAK PROOF™ Technology
Nursing Management for Fever

• When fever occurs, appropriate diagnostics are needed to ascertain possible etiology\(^2\)

• Refractory fever >1-2hrs needs aggressive management\(^2\)

• Institute shivering management strategies\(^2\)

• Monitor for fever burden\(^1\)

Shivering

• Set point has been reset
• Patients will shiver even when goal is normothermia
• Assessment and control of shivering is imperative

Thresholds for Thermoregulatory Responses
Thresholds for Thermoregulatory Responses

Neurogenic / Refractory Fever

Elevated set point

Interthreshold range remains constant when set points are shifted

**Bedside Shivering Assessment Scale (BSAS)**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No Shivering</td>
</tr>
<tr>
<td>1</td>
<td>Mild Shivering, localized to neck and / or chest</td>
</tr>
<tr>
<td>2</td>
<td>Shivering, neck and / or chest and &lt;2 extremities</td>
</tr>
<tr>
<td>3</td>
<td>Intermittent generalized shivering, &gt;2 extremities</td>
</tr>
</tbody>
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Counter Warming

- May reduce incidence of shivering\(^2\)
- Tricks skin receptors into believing the body is warm\(^2\)
- Warm air circulating may be used to cover these areas\(^1\)

Summary

• It is important to properly manage patients receiving targeted temperature management

• You must be dedicated to shivering control in order to effectively cool patients or to maintain normothermia

• Fever in critically ill patients is associated with worse outcomes and length of stay
List of References