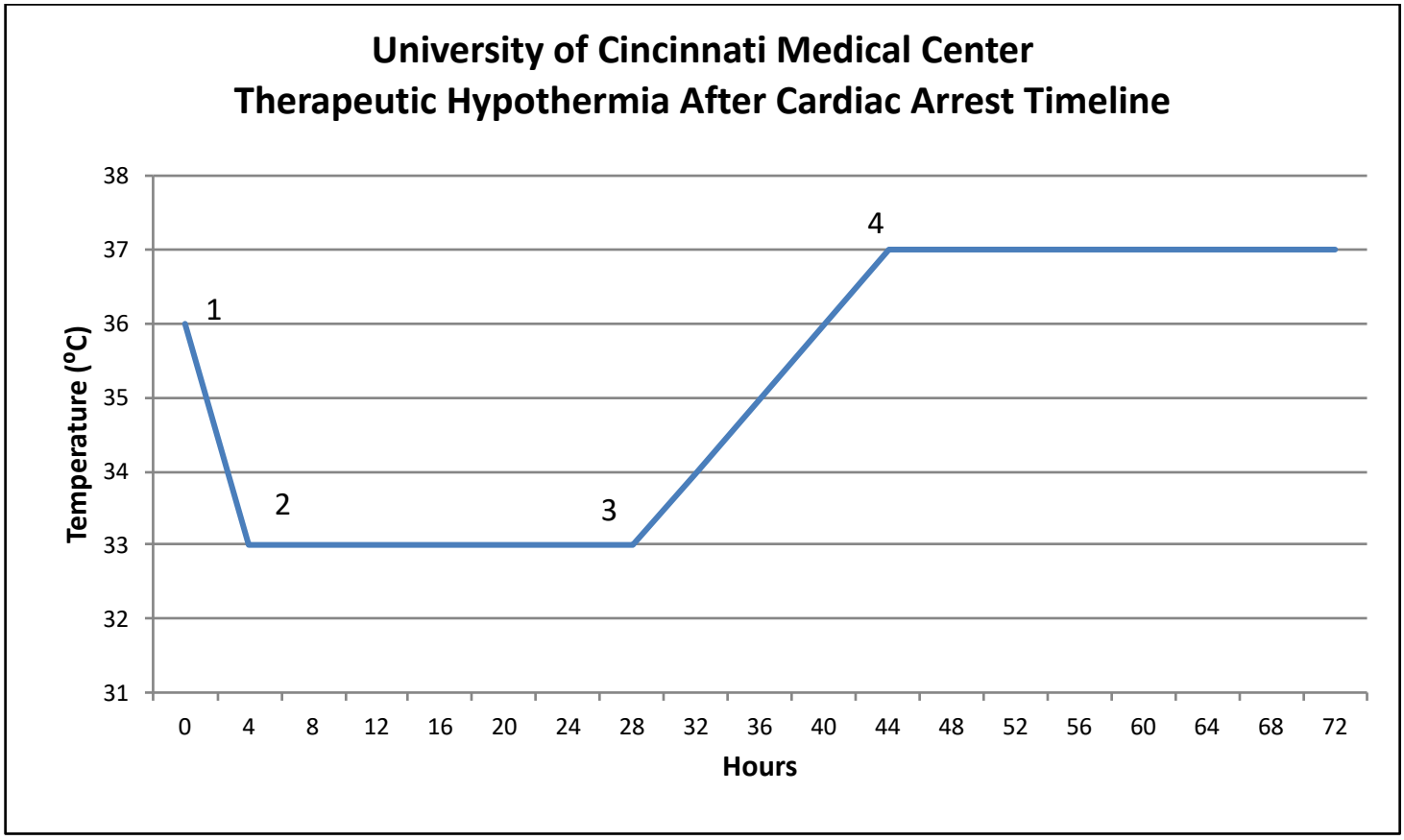
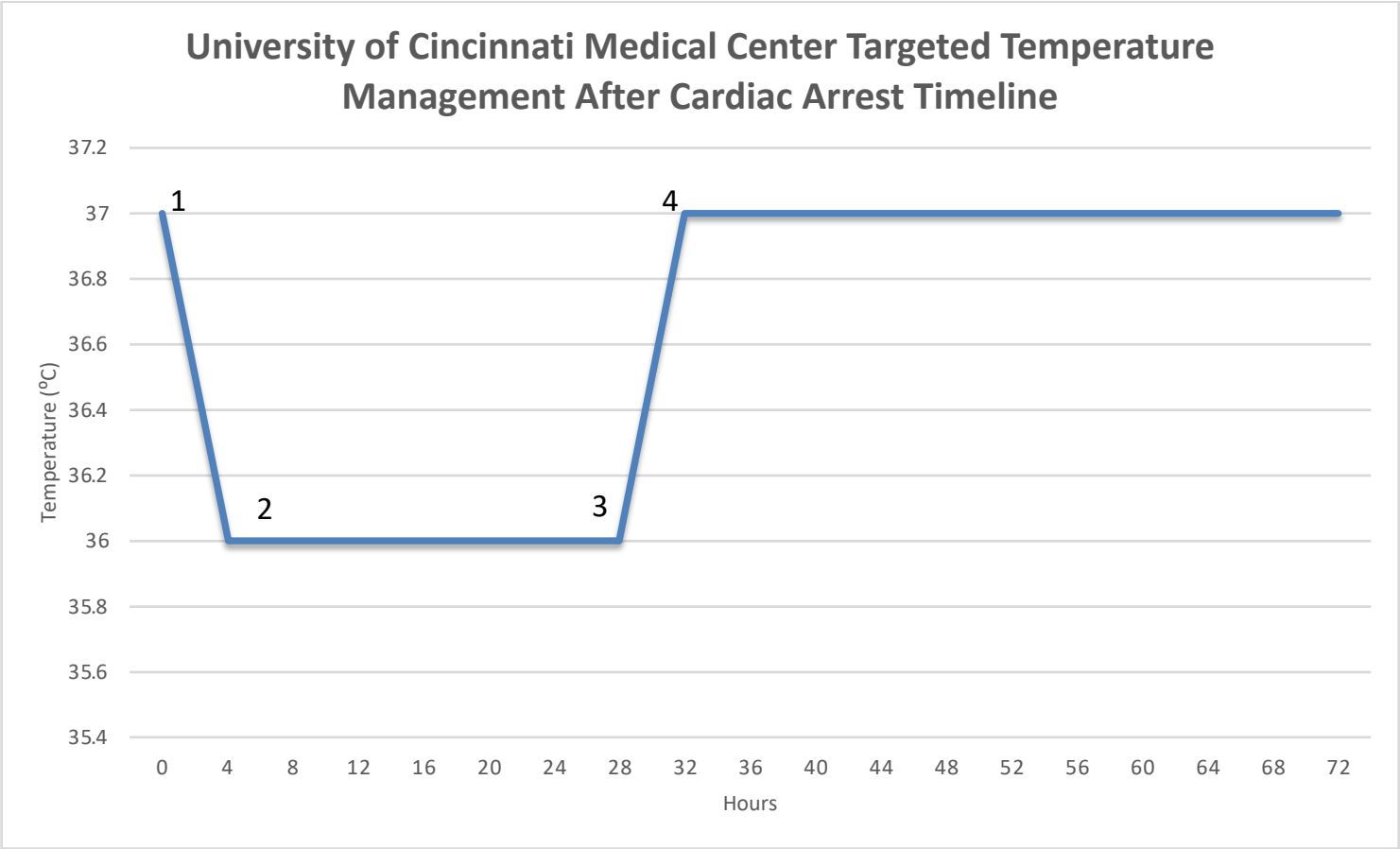
UC Health University Hospital
Targeted Temperature Management After Cardiac Arrest Protocol
Updated July 2018



1 Induction (0-4 hours)
2 Maintenance (24 hours)
3 Rewarming (0.25°C/hour)
4 Maintenance at 37°C (44-72 hours)

This is a 4 phase, 72 hour protocol of strict temperature control, during which the patient will be cooled to target temperature (33°C) WITHIN 4 HOURS of return of spontaneous circulation (ROSC), maintained at 33°C for 24 hours, gradually rewarmed at 0.25°C/hr to 37.0°C, then maintained at 37.0°C for the remainder of the 72 hours after ROSC. This will be approximately 44 hours of controlled euthermia after the rewarming period.



1 Induction (0-4 hours)
2 Maintenance (24 hours)
3 Rewarming (0.25°C/hour)
4 Maintenance at 37°C (44-72 hours)

This is a 4 phase, 72 hour protocol of strict temperature control, during which the patient will be cooled to target temperature (36°C) WITHIN 4 HOURS of return of spontaneous circulation (ROSC), maintained at 36°C for 24 hours, gradually rewarmed at 0.25°C/hr to 37.0°C, then maintained at 37.0°C for the remainder of the 72 hours after ROSC. This will be approximately 44 hours of controlled euthermia after the rewarming period.

Guidance:

Patient develops Return of Spontaneous Circulation (ROSC) after period of pulselessness:

Perform aggressive post-ROSC care as indicated
Aggressively Search for cause of arrest
*NOTE: **IF PRIMARY CARDIAC CAUSE OF ARREST IS SUSPECTED, REPERFUSION THERAPY AND INDUCTION OF HYPOTHERMIA SHOULD BOTH OCCUR AS SOON AS POSSIBLE WITHOUT DELAYING ONE FOR THE OTHER.**
-Both early reperfusion therapy and early initiation of therapeutic hypothermia have been shown to improve functional outcomes after cardiac arrest. Thus, it is imperative that early cooling to target temperature is pursued simultaneously with early reperfusion therapy.
Review Inclusion/Exclusion Criteria (below):

- **Neurocritical Care should be consulted for ALL patients who meet the below inclusion criteria**
- **ALL patients who meet the inclusion criteria below, regardless of any exclusions to hypothermia therapy, should undergo strict temperature management and PREVENTION OF FEVER. *Exclusion criteria are for 33°C only***
- **The decision regarding 33°C or 36°C will be between the consulting NCC team and the primary team, taking into account current best practice, available literature and pertinent patient characteristics**
- **If the patient meets the inclusion criteria below and exclusion is not present, the patient should be cooled to 33°C or 36 °C per the protocol below. This should be the vast majority of cases**

Inclusions:
Cardiac Arrest with Return of Spontaneous Circulation
Not Following Commands
Trauma is not the cause of the arrest
No DNR/DNI

Exclusions:
Patient is Currently Following Commands
Trauma is the cause of the arrest
Patient is Age ≤ 15:
-Consider transfer to CCHMC as appropriate
Known Intracranial Hemorrhage or Stroke
Existing DNR or DNI orders
Hypothermia as the CAUSE of the patient's cardiac arrest
-Actively rewarm the patient

Precautions:

- Major surgery (requiring use of the Operating Room) within 1 week:
  -Consult performing surgeon prior to initiation
- Female Age < 55 years:
  -Check Urine HCG:
    -If pregnant, consult Maternal-Fetal Medicine prior to initiation
- Presenting temperature is < 32 °C (and hypothermia is NOT cause of the arrest) and all teams involved decide to target 33 **°C**:
  -**PASSIVELY** rewarm until temperature of 32°, and then initiate protocol to maintain temperature 32-34°C
- Known Intrinsic Coagulopathy:
  -Discuss with Neurocritical Care prior to initiation
    *Note: Therapeutic antiplatelet or anticoagulation therapy is NOT a contraindication to inducing hypothermia after cardiac arrest.
- Difficulty maintaining MAP ≥ 70:
  -May use vasopressors and ionotropic medications.
  -If continued difficulty, may still induce hypothermia on a case-by-case basis in conjunction with Neurocritical Care.
- Greater than 12 hours after Return of Spontaneous Circulation (ROSC):
  -Discuss with Neurocritical Care prior to initiation
- Pulseless for greater than 60 Minutes:
  -Discuss with Neurocritical Care prior to initiation

Initiate Protocol (Document Start Time): Goal is to reach target temperature (32-34°C) within 4 hours:

- Open "Therapeutic Hypothermia After Cardiac Arrest Order Set" in EPIC

  ***Note: The order set contains pre-checked orders designed to be "default" orders specific to the hypothermia protocol only. However, each patient and situation will be different.**
  PLEASE REVIEW the order set in each case to ensure the desired orders are placed for each individual patient.

- Consult Neurocritical Care Fellow (PAGER #513-820-0074 OR NSICU fellow phone: 688-5836)
  -Indication: Induction of Hypothermia After Cardiac Arrest
    *Note: Do this for ALL non-traumatic cardiac arrests to discuss implementing the hypothermia protocol. If the decision is made not to induce hypothermia, the specific reason should be clearly documented.

Induction Phase:

Onset: Begin within 1 hour of ROSC
Duration: Until target temperature (33°C or 36 °C) reached
(Goal < 4 hours from admission)

1. Initiate Cooling Measures:
   -Expose the Patient
   -If possible, turn the room thermostat off/down
   -For goal target temperature:
     -Apply ICE PACKS to the neck, axilla, torso, trunk, and groin
       -Leave extremities exposed unless surface counter-warming is needed
       -Place cooling fan over patient
       -If not already given, administer 30 mL/kg (or 2L) saline at 4°C IV Bolus:
         -Pre-cooled saline located in ED refrigerator

-Can also be created by placing 2 L NS or LR in a basin with an ice-water slurry for 30 minutes.
-Should be done through peripheral IV if possible
-Must be done under pressure to avoid rewarming of the fluid
-May place IV tubing in ICE to avoid rewarming during administration
-Do NOT repeat if already performed by EMS or other provider

Targeted Temperature Management Devices

Optimal device to be selected by NCC and primary teams based on patient need

- Obtain continuous core temperature monitoring
  - Rectal/esophageal probe: ensure rectal probe is inserted effectively and frequently check placement, physician to insert esophageal
  - Bladder: Per Bard - reference bladder temp is accurate regardless of urine flow
  - PA catheter: Highly accurate but impacted by IV infusions
- Preferably two temp sources, one connected to temperature machine, one to monitor to ensure accuracy
- If the temp connected to the temperature machine is inaccurate, the therapy can have significant interruptions

Arctic Sun surface temperature management

- Place pads
-Apply to dry skin, no need to shave hair
-Order extra "universal pad" for obese patients, or in situations where normal pads are not appropriate (wounds, etc.)
-Do not bathe under intact pads
-Change every 5 days or when pads no longer adhere to skin
-Consider applying fresh defibrillator pads before applying arctic sun pads
-Select "Hypothermia" – set machine to 33 or 36 based on NCC orders
-Set time to cool at 4 hours
-Quick start guide - http://www.medivance.com/pdf/1201-85.pdf
-When transporting the patient, press "stop"
-This will return water from the pads (takes 30 seconds)
-"Pinch, push, pull" to disconnect the lines

Alsius Thermogard

-Neurocritical Care Fellow/Nurse Practitioner for cooling catheter placement if arctic sun not used:
-Set Machine to "Pre-Cool" and connect tubing
-Default Cooling Catheter will be "ICY-Catheter" (9.3 Fr, 38 CM, 3 cooling balloons) via femoral approach, preferably under ultrasound guidance UNLESS patient has IVC filter.
-If IVC filter is present, use "Cool-Line" catheter via Internal Jugular or Subclavian Vein.
*Both must be inserted under sterile conditions, and under supervision of the Neurocritical Care team

Thermogard Setup:
-If using catheter, while catheter is being placed, plug-in Thermogard and set to "*Protocol*"
-Set Thermogard goal temp 33°C or 36 **°C**
-Set Thermogard rate to "*Max Power*" and connect to catheter

2. Raise HOB to 30º
3. Diet: No supplemental nutrition until rewarming complete
4. Place patient on "Bed Rest"
5. Initiate Continuous Vital Sign Monitoring:
    - -Cardiac Monitoring
        - -via 3 lead monitor
        - -observe for changes in cardiac rhythm
    - -Pulse Oximetry
        - -Goal SaO2 95-98%
    - -Blood Pressure:
        - -Initial noninvasive monitoring is acceptable
        - -Insert arterial line as soon as clinically feasible
        - -Maintain MAP 70-110 UNLESS CONTRAINDICATED (ex. in some cases of CHF or ACS):
            - -May use Norepinephrine drip to maintain MAP > 70 mmHg
            - -May use Nicardipine or Nitroglycerin drip to maintain MAP < 110 mmHg
    - -Respiration:
        - -RT should remove humidifier from the ventilator
        - -RT should decrease ventilator circuit temperature
        - -RT should perform immediate in-line suction and aggressive pulmonary toilet
        - -Obtain ABG with initial labs, and adjust ventilator settings accordingly
            - -Titrate FIO2 and PEEP to maintain SaO2 95-98%, and FIO2 100-300 mmHg
            - -Titrate Respiratory Rate and Tidal Volume to PaCO2 35-45
                - ***Note: hypoxia, hyperoxia, hypocapnia, and hypercapnia are all associated with poor neurological outcomes. It is imperative to maintain all PaO2 and PaCO2 values within the above range.**
    - -Temperature:
        - -Insert both a Foley AND Esophageal Temperature Probe if possible
            - Note: Esophageal probes are contraindicated in suspected esophageal rupture
            - -IF a Foley or an esophageal probe is not available or is contraindicated (see above), a rectal temperature probe may be used
            - -DO NOT use a tympanic or axillary temperature for monitoring
6. Draw Initial Labs if not already done:
    - -CBC with differential, PT/PTT/INR
        - -Both to monitor any needed anticoagulation as well as to aid in monitoring for bleeding complications
    - -Troponin-I
        - -Should be checked on every patient after cardiac arrest
        - -In addition to its role as an indicator of primary ischemic heart disease, troponin may also serve as a potential marker of end organ damage.
    - -Liver Function Tests, Lipase
        - -Elevated liver function tests as well as lipase may aid in diagnosis of the underlying disease as well as serve as a potential marker of end organ damage. Hypothermia may also be associated with increased risk for pancreatitis.
    - -Arterial Blood Gas
        - -It is crucial to maintain PaCO2 and PaO2 within the normal rage (see below)
    - -Lactate
        - -Serves as a marker of end organ damage (see below)
    - -Renal Panel, free Calcium, Magnesium, Phosphorous
        - -Electrolyte shifts are common with temperature changes, and should be monitored frequently during the protocol (see below)
    - -Urinalysis, Urine Culture
        - -To monitor for urinary tract infection

-Urine HCG (if female age < 55)

7. Obtain Initial ECG if not already done
8. Obtain Initial Imaging:
    -Chest X –Ray
    -CT Scan of the Head without Contrast:
        *Note: MUST be done prior to admission to ICU. However, if it is not the suspected cause of cardiac arrest, this may be delayed until after cardiac catheterization as not to delay coronary intervention.
9. Repeat Following Labs every 6 hours during induction, maintenance and rewarming:
    -Blood Gas:
        -Analyze at patients ACTUAL body temperature (see below)
        -Maintain PaCO2 35-45
        -Maintain PaO2 100-300
    -Lactate
        -Maintain down trending Lactate
    -Renal Panel:
        -Maintain K > 4.0
    -free Calcium:
        -Maintain in "high-normal" range
    -Magnesium:
        -Maintain Magnesium > 2.0
    -Phosphorous:
        -Maintain in "high normal" range
10. Initiate and maintain analgosedation:
    -Titrate to RASS -4 to -5
        Fentanyl bolus and infusion
        *Note: May be used in combination with anti-shivering measures (see below)
        *Note: Do NOT initiate paralysis without proper sedation (RASS -4 to -5)
        *Note: Sedation may be weaned once temperature > 36.5 and train of four is 4/4
11. Initiate Shivering Assessment:
    -Assess every 30 minutes during Phase I (Induction 0-4 hours)
    -Assess every hour during Phase II (Maintenance 24 hours)
    -Assess every 30 minutes during Phase III (Rewarming @ 0.25°C/hr)

    -Implement ***Bedside Shivering Assessment Scale*** (BSAS) (goal = 0):
        0 = **None:** No Shivering noted on palpation of the masseter, neck or chest wall
        1 = **Mild:** Shivering localized to the neck, and/or thorax only
        2 = **Moderate:** shivering involves gross movement of the upper extremities (in addition to the neck and thorax)
        3 = **Severe:** shivering involves gross movements of the trunk and upper and lower extremities

12. Initiate Anti-Shivering Measures

Baseline interventions done for all patients. Upon BSAS assessment as above, a stepwise progression should occur from steps A thru D, if the patient continues shivering. Meperidine and magnesium may be used prior to progressing from one step to the next, if appropriate. Additionally, continuous infusions may be titrated to higher doses, if the patient shivers again after the introduction of the agent, prior to progressing to the next step.

Baseline interventions for all patients:

1. Surface Counter warming:
-Warm blankets applied to exposed distal upper and lower extremities
-Once cooling device placed, Bair Hugger may be applied to entire skin
2. Buspirone 30 mg orally every 8 hours for 24 hours (consider dose reduction in severe renal impairment)
3. Acetaminophen 1000 mg orally every 6 hours for 24 hours
4. Magnesium sulfate 1 gram every hour prn shivering (BSAS > 1) or if magnesium serum concentration < 2.5 mg/dL

Step-wise approach if patient shivers after introduction of baseline interventions

A. For Shivering Scale $\geq$ 1 refractory to baseline interventions (surface counter warming, buspirone, acetaminophen and magnesium)

   Meperidine 50 mg intravenous push q 30 minutes prn BSAS $\geq$ 1 (maximum of 2 doses before progressing to next phase)
   -Use with caution in patients with renal impairment

B. For Shivering Scale $\geq$ 1 refractory to baseline interventions and meperidine:

   Initiate fentanyl continuous infusion at 50 mcg/hr*

   *If patient is already on fentanyl infusion:

   Initiate dexmedetomidine continuous infusion at 0.5 mcg/kg/hour

C. For Shivering Scale $\geq$ 1 refractory to baseline interventions, meperidine, fentanyl and dexmedetomidine infusions

   Initiate propofol continuous infusion at 25 mcg/kg/min

D. For Shivering Scale $\geq$ 1 refractory to baseline, meperidine, fentanyl, dexmedetomidine and propofol infusions:

   Initiate Neuromuscular Paralysis:
   Rocuronium single dose 0.6 mg/kg (preferred agent)

   If Rocuronium fails:
   Cisatracurium
   -If bolus is desired, 0.15 mg/kg IV X 1
   -1-3 mcg/kg/min continuous infusion

Note: Paralysis should never be used alone to control shivering. Paralysis should only be initiated once patient appropriately sedated (consider use of BIS monitor per Continuous Infusion Neuromuscular Blockade policy [UCH-RX-MED MGMT-109-01])

13. Initiate Glycemic Control:
    -q 6 hr glucose checks via arterial or venous catheter unless indicated more frequently due to medical conditions
    -Avoid finger stick method, as peripheral vasoconstriction may lead to inaccuracy
    -Maintain Blood Glucose 100-180 mg/dl:
    -Hypothermia may induce hyperglycemia
    -Initiate glycemic control per ICU protocol
    -Consider early insulin drip if initial glucose > 180 mg/dL
14. Monitor Urine Output: Goal > 0.5cc/kg/hr throughout the protocol
15. Initiate Anti-Seizure Measures (Neurocritical Care Fellow):
    -Neurocritical Care Fellow should initiate Continuous Video EEG Monitoring to monitor for seizure activity as soon as possible. This should continue until rewarming is complete and all paralytics are discontinued (unless seizures are diagnosed)
    -If seizures are diagnosed, they should be aggressively treated

<u>Maintenance Phase</u>:

Onset: Patient reaches goal temperature (32-34°C or 36 °C):
Duration: 24 hours

No change to Alsius Thermogard Setting ("*Max Power*")
No change to Arctic Sun settings ("*Hypothermia*")

1. Monitor vital signs as above (see "Induction Phase"):
   -Strictly maintain temperature 32-34°C or 36 °C
   -Contact the Neurocritical Care fellow for inability to reach target for longer than 30 minutes (or more than once per hour) for possible troubleshooting.
   -Continue to maintain MAP 70-110 via measures noted above
   -Continue to target PaCO2 and PaO2 parameters as above
2. Continue Respiratory Measures as above (see "Induction Phase"):
   -Hypothermia decreases oxygen requirement and CO2 production, adjust ventilator settings accordingly.
3. Continue Sedation as above (see "Induction Phase")
4. Continue Anti-Shivering Measures as Above (see "Induction Phase")
   -Shivering checks can be done every hour during maintenance phase unless there is difficulty maintaining goal temperature.
   -If neuromuscular paralysis has been applied, continue train of four monitoring q 1 hour until paralysis is discontinued
5. Continue Glycemic Control as above (see "Induction Phase")
6. Check Following Labs q 6 hours during maintenance phase:
   -Blood Gas:
   -Analyze at patient's ACTUAL body temperature (see below)
   -Maintain PaCO2 35-45
   -Maintain PaO2 100-300
   -Lactate
   -Continue to maintain stable or down trending lactate
   -Renal Panel
   -Maintain K > 3.5 mmol/L
   -free Calcium
   -Maintain in "high-normal" range

-Magnesium
-Maintain Magnesium > 2.0 mg/dL

-Phosphorous
- Maintain in "high-normal" range

7. Check Following Labs Daily:
-CBC
-PT/INR
-aPTT

Rewarming Phase:

Onset: 24 Hours after Maintenance Phase Initiated (target temperature reached)
Duration: 0.25°C /hr until 37.0°C reached.

Alsius Thermogard

Change Thermogard to "*Rewarm*"
Set Thermogard goal temperature to 37.0°C
Set Thermogard rate to 0.25°C per hour

*Rapid rewarming is harmful to the patient, primarily due to rapid hemodynamic changes and electrolyte shifts. In the absence of a RARE CIRCUMSTANCE that necessitates cessation of the protocol and rapid rewarming, this should ALWAYS be a slow, controlled process at 0.25°C per hour.

*If Rapid rewarming is necessary (see below), may set rate at a maximum of 0.5°C per hour.

Arctic Sun

Change Arctic Sun to *"Normothermia"*
Set Arctic Sun goal temperature to 37.0°C
Set Arctic Sun rate to 0.25°C per hour
http://www.medivance.com/pdf/mt08204.pdf
-May cover in warm blankets, but ***DO NOT USE BAIR HUGGER***

1. Monitor vital signs as above (see "Induction Phase"):
-Continue to maintain MAP 70-110 via measures noted above (see "Induction Phase")
*During rewarming, peripheral vascular beds often dilate, resulting in a decrease in blood pressure that is usually responsive to IV fluid.
2. Continue Respiratory Measures as above (see "Induction Phase"):
-Continue to target PaCO2 and PaO2 as above
*PaCO2 as well as oxygen requirement may increase during rewarming phase. Adjust ventilator settings accordingly to maintain PaCO2 goals as above.
3. Check Following Labs at the start of the rewarming phase, and one time as the patient reaches 37.0°C:
-Blood Gas:
-Analyze at patients ACTUAL body temperature (see below)
-Maintain PaCO2 35-45
-Maintain PaO2 100-300
-Lactate
-Continue to maintain stable or down trending lactate
-Renal Panel:
-Maintain K > 4.0 mmol/L
*Potassium may increase during rewarming phase – use caution when replacing
-free Calcium:
-Maintain in "high-normal" range
-Magnesium:

-Maintain Magnesium > 2.0 mg/dL

-Phosphorous

-Maintain in "high normal" range

4. Continue anti-shivering methods as above (see "Induction Phase")
   -If neuromuscular paralysis has been applied, continue train of four monitoring q 1 hr for the duration of the paralysis. Paralysis should ideally be discontinued once temperature of 36.5°C has been reached. Initiate above anti-shivering measures to control shivering beyond this point.
5. Continue sedation measures as above (see "Induction Phase")
   -Continue sedation titration to RASS -2
   -Sedation should NOT be weaned until neuromuscular paralysis has been discontinued and train of four of 4/4 has been obtained.

Maintenance at 37°C:

Onset: Once temperature reaches 37.0°C

Duration: **Approximately 44 hours (until 72 hours post ROSC)**

Once temperature has reached 37.0°C:

Alsius Thermogard

-Set Thermogard to "fever mode" and keep temp at 37.0°C

Arctic Sun Settings

Continue Arctic Sun temperature at 37.0°C

1. Maintain this setting for **the remainder of the 72 hours after ROSC (approximately 44 hours after temperature of 37.0°C is reached)**
   Goal: prohibit hyperthermia within 72 hours of ROSC (~44 hours after 37°C reached):
   -The endovascular cooling device should remain in place during this period.
   -Once patient at 37.0°C, leave patient attached to Thermogard for 44 hours
   -During this period, the patient is at the highest risk of hyperthermia
   -Remain vigilant: If there is any increase in temperature > 37.5°C for > 30 min AT ANY TIME during the protocol, contact Neurocritical Care fellow immediately for troubleshooting.
2. Continue to maintain MAP 70-110 via measures noted above (see "Induction Phase")
3. Continue Respiratory Measures as above (see "Induction Phase"):
   -Continue to target PaCO2 and PaO2 as above
   *PaCO2 as well as oxygen requirement may increase during rewarming phase. Adjust ventilator settings accordingly to maintain PaCO2 goals as above.
4. Patient may resume electrolyte measurement and replacement per ICU protocol, if indicated
5. Check Following Labs at 48 hours after ICU admission:
   -Blood Culture
   -Urine Culture
   -Sputum Culture (BAL, PAL)
6. 72 hours after ROSC (approximately 44 hours after 37.0°C is reached), the protocol is complete.
   -Obtain different mode of IV access.
   -Disconnect from Thermogard and remove Cooling Catheter
   -Neurology should be consulted for neuroprognostication (see below)

Managing Common Issues:

Bradycardia:

Bradycardia alone (even to as low as 35 bpm) may occur during induced hypothermia and, except in rare cases, is NOT a reason to discontinue the protocol. If bradycardia is severe, associated with persistent hypotension, and is not responsive to fluid and vasopressor therapy, a decision in conjunction with Neurocritical Care may be made to discontinue the protocol and rewarm the patient to 36°C. In this case, the endovascular device should be left in and temperature should remain at 36°C for the duration of the "maintenance" phase. Rewarming can then proceed to 37°C per protocol.

Lactate:

Due to multiple factors (decreased cardiac output, shivering, lab measures, vasopressor administration), lactate levels will often be mildly elevated (usually $\leq$ 5 mmol/L) during hypothermia. Once patient has reached target temperature, lactate should remain stable. Thus, the lactate trend during the protocol should be noted. An increasing lactate during the maintenance phase may indicate under resuscitation, which should be treated aggressively.

Methods of Temperature Measurement:

The benefit of therapeutic hypothermia relies on the induction and maintenance of an appropriate core body temperature without overcooling or accidental rewarming, both of which may be harmful to the patient. For this reason, temperature must be monitored closely and the method used to do so must be accurate and continuous. Of the methods available, both esophageal and bladder measurements have been shown to most accurately reflect core body temperature in most circumstances. Due to the importance of continuous temperature measurement and the possibility of inaccuracies, it is safest to measure BOTH esophageal and Foley temperatures continuously throughout the protocol. This requires a temperature-sensitive Foley catheter to be placed immediately as the protocol begins, followed by an esophageal probe as soon as possible.

Rectal temperature probes, although often accurate when core body temperature is static, have been shown to lag behind changes in core body temperature. This "probe lag" may lead to the over-cooling and inappropriately rapid rewarming. Thus, rectal probes should not be used during the protocol unless both esophageal and Foley probes are unavailable or contraindicated.

Tympanic Membrane and axillary temperature measurements do not provide continuous temperature monitoring and should not be used to monitor temperature in patients undergoing therapeutic hypothermia.

Dysrhythmia:

Hypothermia-induced dysrhythmias generally do not occur unless temperatures fall $\leq$ 30°C, and hypothermia-related ventricular fibrillation is rare unless temperature is $\leq$ 28°C. If temperatures this low do occur, monitor closely for dysrhythmias. If hemodynamically unstable dysrhythmias do occur at the low temperatures noted above, rewarm the patient rapidly to 32°C.

Hypotension:

Hypotension often occurs during the hypothermia protocol. If the source is cardiogenic, it is often the post-arrest state (and not the hypothermia) that is the cause. During rewarming, peripheral vasodilation may be the cause, and this is usually responsive to IV fluids. Except in rare cases, the hypothermia protocol should NOT be stopped due to hypotension. Continue to give hemodynamic support as above. If hypotension continues despite these measures, contact Neurocritical Care to discuss further options, which may include rewarming.

Diuresis:

Hypothermia induces diuresis in most patients. This so called "cold diuresis" may lead to an artificially high urine output. This may result in both a relative hypovolemia as well as an overestimation of the patient's volume status if conventional urine output goals are applied. Thus, a slightly higher goal urine output of 1 cc/kg/hr is reasonable in most cases to ensure continued adequacy of intravascular volume. Further, hypothermic patients are especially at high risk of hypotension during the rewarming phase, when 24 hours of diuresis has occurred along with peripheral vasodilation occurring with the increase in temperature. Along with higher urine output goals, it may be beneficial to increase Intravascular fluid administration just prior to rewarming.

Bleeding:

The antiplatelet and antithrombotic effect of hypothermia is low (especially at a temperature above 34 °C). Further, most bleeding risk associated with hypothermia is limited to an impaired ability to generate new clots (not necessarily in disruption of clots already formed) and is increased in the setting of acidosis. Thus, for minor bleeding (i.e. around IV sites, sites of minor trauma, etc.) do NOT stop the hypothermia protocol. Instead, correct acidosis and minimize any further trauma to the patient. For cases of clinically significant bleeding (ex. massive gastrointestinal bleeding, intracranial hemorrhage, etc.) early rewarming to 36^{o}C or higher may be initiated, but ONLY in consultation with the Neurocritical Care Fellow.

Electrolyte Shifts:

Decreases in temperature often lead to intracellular potassium shifts without depletion in whole body potassium stores. This corrects during rewarming, which, if aggressively replaced during low body temperatures, may lead to hyperkalemia as the patient is rewarmed. Use caution when replacing potassium in these patients. Further, replace magnesium (>2.0), free Calcium ("high-normal"), and phosphorous (normal) aggressively as they may decrease during hypothermia.

Arterial Blood Gases:

It is imperative that the lab knows the patient's current temperature when analyzing blood gases. This should be communicated directly to the lab when sending the sample, and should be checked to confirm the temperature used for analysis is listed on the result and is consistent with the patient's actual body temperature. Lab analysis of PaCO2 and PaO2 at the incorrect temperature may lead to unrecognized respiratory alkalosis and/or hypoxia. In cases where it is impossible for the lab to measure at the patient's actual body temperature (rare) and a second sample cannot be sent, values may be adjusted as follows:

<u>For each 1 °C below 37°C</u>:

-PaO2 – 5 mmHg = corrected value

-PaCO2 – 2 mmHg = corrected value

-pH + 0.012 = corrected value

Diagnosis of Infection:

Since the patient's hemodynamic, cellular, and thermoregulatory response to infection will be blunted during hypothermia, it is necessary to monitor closely for the development of infection using other methods. Arctic Sun may be used to trend the water temperature used to maintain core body temperature. After goal temperature is reached, further decreases in water temperature below 20C may indicate low-grade fever and below 10C indicate high-grade fever. Daily chest x-rays as well as screening blood, urine, and sputum cultures (BAL or PAL) every 48 hours should be obtained while temperature is being regulated. Aggressive treatment should be initiated when there is evidence of infection, and the patient, while hypothermic, should be treated as immunocompromised. In general, evidence of

infection is NOT an indication for early rewarming, but should be discussed on a case-by-case basis with the Neurocritical Care fellow.

Medication Administration:

Do not administer any medications labeled **"Do Not Refrigerate"** through the Icy-Cath or Cool-Cath while being used for active cooling. These medicines may precipitate in the central line. These medications may be administered via a separate peripheral or central line – even while the patient is hypothermic. The cold central line causes the precipitation, not the hypothermic patient.

Shivering:

Shivering is an innate and effective response to a decrease in core body temperature. It is problematic for the post-cardiac arrest patient, as it increases cerebral oxygen consumption, systemic oxygen consumption, CO2 production, and increases cardiac output. Further, it can severely impede achievement and maintenance of therapeutic goals. Thus, it should be monitored closely and aggressively treated. If the Anti-Shivering Protocol is applied, patients should be watched closely to ensure effectiveness of the sedative and nonmedical measures. If neuromuscular paralysis is employed, the need for this should be frequently reassessed, and paralysis stopped when indicated.

Surface counter warming is a nonmedical therapy that applies heat to the skin while maintaining the appropriate core body temperature. This results in a perceived increase in body temperature by the hypothalamus, which results a decrease in shivering. If the cooling catheter has not been placed, and ice packs and a cooling blanket have been applied, surface counter warming may be achieved by placing warm blankets on the patient's exposed distal upper and lower extremities. Once the cooling catheter has been placed, a Bair Hugger may be used over the patient's skin to achieve this purpose.

Seizure Monitoring:

Patients who have undergone a cardiac arrest are at high risk for seizures. This is especially detrimental for these patients, as seizures can increase cerebral metabolic rate and contribute to reperfusion injury. Since these patients will be sedated and may have received neuromuscular paralysis, neurocritical care should initiate Continuous Video EEG monitoring as close to the initiation of hypothermia as possible. If seizures are detected by EEG monitoring, these should be treated aggressively.

Neuroprognostication:

Neurologic prognosis post cardiac arrest treated with hypothermia is controversial. The optimal timing for appropriate prognosis is unclear. The primary team should refrain from any attempt at prognosis until at least 72 hours post cardiac arrest. This is especially important if the patient remains neurologically altered or comatose upon rewarming. Recent literature has demonstrated good neurologic outcomes despite initially poor neurologic exams post-rewarming. Additional tests such as MRI or EEG may be employed to assist with prognosis. Neurology should be consulted during the hypothermia period to assist with the long-term prognosis once rewarming is complete.

Managing Fluctuations in Temperature:

Wide swings in temperature may be harmful in the post-arrest period and should be prevented. Patients should NOT be overcooled ($< 32^{o}C$) or allowed to rewarm in an uncontrolled fashion after induction. To prevent this, a bladder OR an esophageal temperature probe should be placed as soon as possible after the patient's arrival. Temperature should be monitored closely and corrective measures should be taken immediately if the patient becomes overcooled or rewarming begins to occur. Further, placement of an endovascular device should occur as soon as possible after the patient's arrival, regardless of the target temperature.

Hyperthermia:

Fever can be damaging to the injured brain and may impede neurologic recovery after cardiac arrest. In all cases of post-arrest management, regardless of the initial target temperature, hyperthermia (> 37.5^{o}C) should be avoided for AT LEAST 72 hours after return of spontaneous circulation, preferably longer.

Stopping Hypothermia:

Though it is rare, there are circumstances in which the patient must be rewarmed prior to the rewarming phase. This should only be done in conjunction with Neurocritical Care. If this is necessary, the patient should be rewarmed at a maximum rate of 0.5^{o}C (vs 0.35^{o}C)/hr to 36^{o}C. In general, temperature should be maintained at 36^{o}C until the rewarming phase, at which time the care should continue as per protocol. There may be very rare cases in which a higher temperature is needed (for example, in some cases of acute bleeding). In this case, though a temperature above 36^{o}C is allowable, the patient should be still kept at a temperature < 37.5^{o}C at all times.

References:

Arrich, J, Holzer, M et al (2012). "Hypothermia for Neuroprotection in Adults after Cardiopulmonary Resuscitation." *Cochrane Database Syst Rev* 2012;9:CD004128

Badjatia, N, Strongilis, E (2009). "Metabolic Benefits of Surface Counter Warming During Therapeutic Temperature Modulation. *Crit Care Med* Vol 37(6), June 2009, pp 1893-1897

Brenner, Stein et al (2012). "Association Between Early Hyperoxia and Worse Outcomes After Traumatic Brain Injury. *Arch Surg* doi:10.1001/archsurg.2012.156

2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. Dec 13 2005;112(24 Suppl):IV1-203.

Bernard SA, Gray TW, Buist MD, et al. Treatment of comatose survivors of out-of-hospital cardiac arrest with induced hypothermia. *N Engl J Med*. Feb 21 2002;346(8):557-63.

Bernard SA, Jones BM, Horne MK, et al (1997). "Clinical Trial of Induced Hypothermia in Comatose Survivors of Out of Hospital Cardiac Arrest." *Ann Emerg Med* 1997 Aug;30(2):146-53

Bro-Jeppesen, J, Hassager, C et al (2013). "Post-Hypothermia Fever is Associated with Increased Mortality after Out of Hospital Cardiac Arrest". *Resuscitation* 2013(Dec);84(12)1734-1740

Caufield, F, Rachabattula, S et al (2011). "A Comparison of Cooling Techniques to Treat Cardiac Arrest Patients with Hypothermia." *Stroke Res Treat* 2011;2011:6090506

Choi, AH, Sang-Bae, K et al (2011). "Prevention of Shivering During Therapeutic Temperature Modulation: The Columbia Anti-Shivering Protocol". *Neurocrit Care* 14:389–394

Cronberg, T, Horn, J et al (2013). "A Structured Approach to neurologic Prognostication in Clinical Cardiac Arrest Trials." *Scandinavian Journal of Trauma, Resuscitation, and Emergency Medicine* 2013;21(45)1751-7

Flint, AC, Hemphill, JC et al (2007). "Therapeutic Hypothermia After Cardiac Arrest: Performance Characteristics and Safety of Surface Cooling With or Without Endovascular Cooling." *Neurocrit Care* 2007;7(2)109-118

Gillies, MA, Pratt, R et al (2010). "Therapeutic Hypothermia after Cardiac Arrest: a Retrospective Comparison of Surface and Endovascular Cooling Techniques." *Resuscitation* 2010 Sep;81(9):117-112

Grossestreuer, AV, Abella, BS et al (2013). "Time to Awakening and Neurologic Outcome in Therapeutic Hypothermia-Treated Cardiac Arrest Patients." *Resuscitation* 2013 Dec, 84(12):1741-1746

Hypothermia after Cardiac Arrest Study Group. "Mild therapeutic hypothermia to improve the neurologic outcome after cardiac arrest [published erratum appears in N Engl J Med 2002; 346 (22): 1756]. N Engl J Med 2002;346(8):549-56.

Leary, M, Grossestreuer, A et al (2013). "Pyrexia and Neurologic Outcomes after Therapeutic Hypothermia for Cardiac Arrest." *Resuscitation* 2013(Aug);84:1056-1061

Lefrant, Muller et al (2003). "Temperature measurement in intensive care patients: comparison of urinary bladder, oesophageal, rectal, axillary, and inguinal methods versus pulmonary artery core method." *Intensive Care Med*. 29(3):414-418

Nielsen, N, Wetterslev, J et al (2013). "Targeted Temperature Management at 33^{o}C vs 36^{o}C after Cardiac Arrest." *NEJM* 213:369:2197-2206

Nolan JP, Morley PT, Hoek TL, Hickey RW; Advancement Life support Task Force of the International Liaison committee on Resuscitation (2003). "Therapeutic hypothermia after cardiac arrest. An advisory statement by the Advancement Life support Task Force of the International Liaison committee on Resuscitation". *Resuscitation* 2003 Jun;57(3):231-5.

Peberdy, MA, Callaway, CW et al (2010). "Post-Cardiac Arrest Care: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care." *Circulation* 2010;122;Suppl3:S768-S786

Tomte, O, Draegni, T, et al (2011). "A Comparison of Intravascular and Surface Cooling Techniques in Comatose Cardiac Arrest Survivors." *Crit Care med* 2011 Mar;39(3):443-449

Zeiner, A, Holzer, M et al (2001). "Hyperthermia after Cardiac Arrest is Associated with an Unfavorable neurologic Outcome." *Arch Int med* 2001;161:2007-2012.