Optimizing Therapeutic Hypothermia for Neonatal Encephalopathy

OBJECTIVE: Therapeutic hypothermia (TH) for neonatal encephalopathy is becoming widely available in clinical practice. The goal of this collaborative was to create and implement an evidence-based standard-of-care approach to neonatal encephalopathy, deliver consistent care, and optimize outcomes.

METHODS: The quality improvement process identified and used the Model for Improvement as a framework for improvement efforts. This was a Vermont Oxford Network Collaborative focused on optimizing TH in the treatment of neonatal encephalopathy. By using an evidence-based approach, Potentially Better Practices were developed by the topic expert, modified by the collaborative, and implemented at each hospital. These included the following: timely identification of at-risk infants, coordination with referring hospitals to ensure TH was available within 6 hours after birth, staff education for both local and referring hospitals, nonsedated MRI, incorporating amplitude-integrated EEG into a TH protocol, and ensuring standard neurodevelopmental follow-up of infants. Each center used these practices to develop a matrix for implementation.

RESULTS: Local self-assessments directed the implementation and adaptation of the Potentially Better Practices at each center. Resources, based on common identified barriers, were developed and shared among the group.

CONCLUSIONS: The implementation of a TH program to improve the consistency of care for patients in NICUs is feasible using standard-quality improvement methodology. The successful introduction of new interventions such as TH to the NICU culture requires a collaborative multidisciplinary team, use of a systematic quality improvement process, and perseverance.

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KEY WORDS neonate, hypothermia, encephalopathy, quality improvement

ABBREVIATIONS aEEG—amplitude-integrated EEG HIE—hypoxic ischemic encephalopathy PBP—Potentially Better Practice TH—therapeutic hypothermia VON—Vermont Oxford Network

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Neonatal encephalopathy due to hypoxia-ischemia occurs in 1 to 6 per 1000 live term births in developed countries. Approximately 15% to 20% of affected newborns die in the postnatal period, and 25% of survivors develop severe childhood disabilities. Until recently, management of hypoxic ischemic encephalopathy (HIE) has been limited to supportive intensive care. Recent clinical trials have evaluated hypothermia as a neuroprotective intervention for HIE.\(^1\)\(^-\)\(^7\) A recent meta-analysis of these trials has demonstrated that therapeutic hypothermia (TH) significantly reduces mortality and neurodevelopmental disability at age 18 to 24 months in neonates with moderate-severe HIE.\(^8\)

The Vermont Oxford Network (VON) Collaborative originated as a pilot project in 1995. Since that time >85 NICUs have participated in 7 quality-improvement collaboratives on neonatal intensive care/quality. The focus of the VON Collaborative quality-improvement projects includes the 6 domains identified by the Institute of Medicine that are incorporated into the project focus, with special emphasis on family-centered care.\(^9\)

Neonatal encephalopathy was a topic group in the 2009 VON Collaborative on Neonatal Intensive Care/Quality, and the work described was conducted by the multidisciplinary topic group consisting of physicians, nurses, neonatal support staff, and family members.

**METHODS**

The VON Encephalopathy Collaborative consisted of 5 centers led by a facilitator, a clinical leader, and a topic expert. The facilitator served as the quality-improvement process guide for the group and consulted with project leaders, VON staff, and other facilitators to coordinate project activity. The clinical leader brought the practical experience of a participating team to plan and guide the groups’ work. The topic expert assisted teams in developing improvement ideas, identifying measurable improvement aims, and implementing practice change. The primary goal of the Encephalopathy Collaborative was to provide consistency of medical care and optimize outcomes in HIE. With the use of an evidence-based approach, Potentially Better Practices (PBPs) were developed by the topic expert. These practices are referred to as “potentially better” rather than “better” or “best” because we believe that until the practices are evaluated, customized, and tested in one’s own NICU, one will not know whether they are truly better or best. After presentation of the PBPs to the collaborative, the group reached a consensus on a final list of PBPs that formed the basis for a plan that each hospital used for implementation. The Model for Improvement\(^10\) was used, incorporating William Edwards Deming’s Plan Do Study Act cycles in the process. Although the methods used were different at each hospital, they addressed issues such as buy-in for change, challenges, and lessons learned. The list of PBPs identified as targets for implementation included the following:

1. **Ensure Timely Identification of Infants With Neonatal Encephalopathy**

**Rationale**

The early identification of infants at highest risk for encephalopathy should be the goal for any TH program. This step is of paramount importance because the therapeutic window during which interventions are helpful in reducing the severity of brain injury is likely to be short.

**Aim**

All infants at risk of encephalopathy who may be eligible for TH should undergo a standardized neurologic exam before 4 hours of age.

**Recommendations**

- Establish a multidisciplinary task-force that includes representatives from Obstetrics and Pediatric Neurology for early identification of encephalopathic infants. This taskforce would develop a list of specific criteria (perinatal sentinel events, need for resuscitation, specific Apgar scores and laboratory parameters [cord gases], and/or presence of seizures), which will prompt a required neurologic exam.

- Create a standardized neurologic exam with the use of a checklist, which would be repeated at set intervals (Appendix 1). Train a specific cohort of examiners to perform the serial exams and document scores. Infants with risk factors, especially abnormal acid-base status
on blood gases, but “mild” encephalopathy on initial evaluation should undergo serial examinations at 1- to 2-hour intervals to document the evolution of encephalopathy in the “TH window” of 6 hours of life.

- If available during this observational period, a full-montage EEG or limited-channel aEEG can assist with evaluation.

**Challenges**

The key challenge in implementation is to standardize the process of timely recognition. There are limited educational resources for training on the standard neonatal neurologic examination, and a video teaching tool demonstrating stages of encephalopathy would be useful to standardize this process. Developing a checklist with a complete definition of terms used in the form may help. Outborn infants pose a specific challenge because expertise in early identification may be limited. Additional documentation may be an added burden.

### 2. Develop a Coordinated System With Referring Hospitals That Ensures TH Is Available for Eligible Infants Within 6 Hours of Birth

**Rationale**

The early identification by referring hospitals of infants at risk of HIE and subsequent timely request for transport to the treating center are essential because the therapeutic treatment window is short.

**Aim**

Provide outreach education to referring centers to facilitate rapid identification and appropriate initial treatment of encephalopathic infants. Provide safe TH on transport to eligible infants.

**Recommendations**

- Create a checklist and educate referring health care teams about eligibility criteria for TH and the importance of timely identification of at-risk infants.
- Educate referring health care teams about appropriate interim temperature management of an infant being referred for TH.
- Create a checklist for those handling incoming calls from referring hospitals to appropriately identify candidates for TH and to give instructions about proper initial temperature management of the infant.
- Create a standard protocol for providing TH on transport.

**Challenges**

The challenges identified included the following: the education of a large number of providers in the community, failure or delay in recognition of eligible at-risk infants, and failure to monitor core temperature of at-risk infants due to lack of awareness or equipment.

### 3. Implement an Evidence-Based Standard Protocol for Providing and Monitoring TH With Continuing Staff Education

**Rationale**

Studies of TH have shown a statistically significant improvement in outcomes for infants with moderate to severe encephalopathy. Although no serious complications have been found in the trials to date, it is important to establish a monitoring system to identify less common or unknown adverse events.

**Aim**

Establish a TH protocol consistent with published trials, including a system to monitor safety and follow adverse events. Develop a system to educate the staff involved in the implementation of TH.

**Recommendations**

- Offer TH according to previously published trials. Due to the potential infrequent use of TH, a simple, readily available protocol should be used. Representatives from neonatology, pediatric neurology, pediatric neuroradiology, nursing, respiratory therapy, physical and occupational therapy, nutrition, social work, and a parent representative should be involved in the implementation of a program, with periodic meetings to review and update the protocol.
- Educational options include physician and nursing in-services on equipment and eligibility criteria, a nursing skills fair, “mock-TH” events, and forming a “playbook” with pictures and step-by-step instructions for setting up the equipment as well as possible pitfalls and their solutions.

**Challenges**

The education of NICU staff regarding the TH protocol takes considerable time and effort and is an ongoing process.

### 4. Implement a Standard Protocol for Obtaining an MRI on Encephalopathic Infants Without Sedation in the First 10 Days of Life

**Rationale**

MRI is the most accurate imaging modality in the evaluation of neonatal encephalopathy. Sedation or anesthesia adds to the cost of the scan, limits the flexibility during which scans may be obtained, and increases risks to the infant. Protocols for nonsedated MRI scans have been developed and have proven to be effective.

**Aim**

Obtain high-quality, nonsedated MRI scans of encephalopathic infants to detect the severity and pattern of brain injury.

**Recommendations**

- Multispecialty team approach between neonatology staff, nursing,
and radiology can address coordination and quality of imaging.

- An MRI-compatible immobilizer can be used to prevent the infant from moving. Monitoring during transport and scanning can be accomplished with MRI-compatible pulse oximetry.

**Challenges**

Institutional challenges may exist surrounding the feasibility of nonsedated MRI techniques for neonates. The acceptance of this technique requires close coordination among teams, a change in unit culture, and perseverance.

**5. Incorporate EEG/aEEG Evaluation as Part of the TH Protocol for Infants With Encephalopathy**

**Rationale**

The role of conventional EEG monitoring in assessing cerebral function, detecting seizures, and predicting neurologic outcome in term neonates is well established. Limited-channel aEEG provides continuous bedside monitoring of cerebral electrical activity, which complements EEG, neurologic examination, and neuroimaging in the evaluation and management of infants with HIE.

**Aim**

All infants at risk of encephalopathy, for whom TH is being considered, should undergo a 1-hour EEG or aEEG monitoring initiated in the first 12 hours of age. All infants who have moderate or severe background abnormalities on initial evaluation should have follow-up EEG studies 12 to 24 hours later to determine prognosis. Infants with seizures on initial evaluation should undergo continuous monitoring with aEEG or EEG for optimal detection and treatment of seizures.

**Recommendations**

- Neonatology and pediatric neurology should explore the feasibility of electrophysiological evaluation as part of the TH protocol. If EEG is not feasible, create a “super-user” team of staff who can initiate aEEG monitoring on all shifts. The team needs to establish a standardized format for aEEG reporting and provide ongoing staff education to ensure proper aEEG data interpretation and documentation.

- Establish threshold for initiating anticonvulsant therapy for electrographic seizures.

**Challenges**

The utility of continuous aEEG monitoring versus periodic EEG evaluation remains unclear. In addition, there are no consensus guidelines on treatment of electrographic seizures or whether monitoring and treating electrographic seizures improve outcome.

**6. Assess the Outcomes of TH Systematically by Providing Standardized Neurodevelopmental Follow-up and Enrolling All Treated Infants in a National Registry**

**Rationale**

As TH is implemented, subtle variation in patient selection and unit protocols can contribute to differences in survival, adverse events, and long-term outcomes for treated infants. Both the National Institute of Child Health and Human Development and the American Academy of Pediatrics caution that if implementing a TH program, clinicians should follow published trial protocols, ensure systematic follow-up of survivors, and submit patient data to registries.

**Aim**

Ensure that patients with moderate-severe neonatal encephalopathy are enrolled in a national registry and that patients treated with TH get neurodevelopmental follow-up.

**Recommendations**

- Ensure that each participating unit has access to a national encephalopathy registry in which eligible infants can be enrolled.

- Provide families with information regarding the registry, the importance of follow-up, contact information, and an information sheet regarding expectations.

- Ensure the availability of a neurodevelopmental follow-up clinic equipped with appropriate personnel to perform a standard neurologic examination and a Bayley Scale of Infant and Toddler Development—III assessment at 18 to 24 months of age.

**Challenges**

Additional resources for data entry into registries and to ensure follow-up may not be readily available. Developmental pediatricians, psychologists, and neurologists may be reluctant to accept the additional patient load.

**Incorporating the Parental Perspective**

Rather than create a separate PBP for the parental perspective, this key component was integral to all 6 PBPs described above. Parental involvement is the key to success of a TH program. A parent representative was an active participant in the quality-improvement process. Neonatal HIE is most often unanticipated for families and caregivers alike. Thus, it is critical to prepare and provide written educational material to families, which helps parents anticipate the neonatal course and empowers them in advocating for their infant. This is especially important for institutions that transport infants to regional centers for TH. Educational material can be created by using perspectives of both former and current parents.
RESULTS

The Encephalopathy Collaborative comprised hospitals differing in demographics, experience, equipment, and facilities. Despite these variations, the group was able to agree on common quality measures, based on the PBPs, and compile cumulative data (Table 1). Due to the inherent variation between centers (size of unit, admission process, ancillary support), each center completed an initial self-assessment report card to prioritize efforts (Fig 1). This report card proved to be the driving force for change.

PBP 1: Ensure Timely Identification of Infants With Neonatal Encephalopathy

The early identification of eligible infants was facilitated by developing criteria that were user-friendly and supported by the literature (Fig 2). A neurologic assessment checklist was developed, approved, and implemented. Although the inclusion criteria seem simple, subjectivity exists in the neurologic exam, and clinical scenarios often needed discussions between providers to determine eligibility. The goal of the standard examination checklist was to make the process and documentation consistent. Educational programs, both in-house and via outreach, were developed and provided to referring centers. Hypothermia centers faced greater challenges in educating referring hospitals with variable expertise and infrastructure. Posters (Appendix 2) were disseminated with criteria and care reminders. Despite the inherent complexity, anxiety, and medicolegal implications surrounding HIE infants, coordinated educational efforts were successful in the identification of eligible infants within the recommended 4 hours (Table 1).

PBP 2: Develop a Coordinated System With Referring Hospitals That Ensures TH Is Available for Eligible Transported Infants Within 6 Hours of Birth

Other centers have reported successful implementation of TH on transport. A detailed management guideline was developed for use by referring hospitals. These guidelines were used with a goal of ensuring a safe transition to TH during transport (Appendix 3). Referring hospitals paid careful attention to core temperature monitoring, resulting in few neonates who experienced hyperthermia or profound hypothermia. In addition, there was a significant increase in the number of infants with documented blood gases within the 1-hour window, making eligibility criteria more consistent (Table 1). Subjectively, this guideline improved team satisfaction during the transport process.

PBP 3: Implement an Evidence-Based Standard Protocol for Providing and Monitoring TH With Continuing Staff Education

A standard inpatient management guideline was developed to ensure consistent implementation of TH across centers. One early identified challenge was reliable core temperature monitoring with both passive and active TH. Conventional methods of external measurements to determine length of esophageal temperature probe placement resulted in variable core temperature values. Process improvement identified the average length of acceptable insertion, because all infants were ≥36 weeks’ gestation. When the insertion depth was standardized to 15 cm in 1 center, a 46% increase in accurate placement was achieved (Fig 3).

PBP 4: Implement a Standard Protocol for Obtaining MRI on Encephalopathic Infants Without Sedation in the First 10 Days of Life

A major improvement story of the group was the creation of a standard protocol to obtain MRI scans in nonsedated infants. All centers developed a process that resulted in successful acquisition of nonsedated MRI scans (Table 1). An example of an improvement story is depicted in Fig 4. Key elements of the process were timing of feedings, coordination with radiology, and an infant immobilizer.

PBP 5: Incorporate EEG/aEEG Evaluation as Part of the TH Protocol for Infants With Encephalopathy

Particularly challenging for the group was the incorporation of aEEG into TH

TABLE 1 Cumulative Data From Each Center Used for Comparison and Benchmarking

<table>
<thead>
<tr>
<th>Encephalopathy Group Comparison Chart</th>
<th>Center 1</th>
<th>Center 2</th>
<th>Center 3</th>
<th>Center 4</th>
<th>Center 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with temperature &gt;38°C before cooling, n</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Average time to goal temperature, minutes</td>
<td>264</td>
<td>299</td>
<td>25</td>
<td>108</td>
<td>71</td>
</tr>
<tr>
<td>Patients with Tmax &gt;38°C, n</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Patients with cord gas measurements within 1 hour, %</td>
<td>74</td>
<td>87</td>
<td>100</td>
<td>100</td>
<td>81</td>
</tr>
<tr>
<td>Patients with arterial blood gas measurements within 1 hour, %</td>
<td>70</td>
<td>52</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Patients with cord and/or arterial blood gas measurements within 1 hour, %</td>
<td>98</td>
<td>88</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Average day of life at time of initial MRI</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Patients with nonsedated MRI, %</td>
<td>94</td>
<td>73</td>
<td>80</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Patients with neurologic exam before cooling, %</td>
<td>76</td>
<td>3</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Patients with neurologic exam 7 d and/or before discharge, %</td>
<td>56</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Parents receiving brochure/handout, %</td>
<td>96</td>
<td>Total unknown</td>
<td>100</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>Patients seen for follow-up within 3 mo, %</td>
<td>72</td>
<td>78</td>
<td>0</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>Total number of cooled patients, n</td>
<td>54</td>
<td>33</td>
<td>5</td>
<td>5</td>
<td>28</td>
</tr>
</tbody>
</table>

Tmax, maximal temperature.
protocols. The key problem with this PBP was the relative inadequacy of the literature and inexperience with this technology. Challenges included the following: (1) availability of equipment, (2) lead application, (3) aEEG interpretation, (4) lack of standard aEEG report documentation, (5) need for continual staff education, and (6) inconsistency in diagnosis and treatment of seizures. One center developed a standardized form for serial documentation of the aEEG evolution, which incorporated standard terminology. The implementation of this standard form improved documentation compliance (Fig 5). However, clinical application remained problematic. At the time of the collaborative, there was limited literature on the role of EEG monitoring in HIE; however, the occurrence of subclinical seizures was recognized.13–15 Feasibility issues with EEG made aEEG a better choice despite its limitations. More successful centers were able to partner with pediatric neurology in education, interpretation, and management. Despite these challenges, by the end of the collaborative aEEG monitoring was implemented successfully in all units.

**DISCUSSION**

The Encephalopathy Collaborative was successful in identifying individual unit priorities, reaching a consensus on the PBPs, and adapting them to make this initiative successful. Each participating center rapidly recognized that implementation of a TH program would require a culture change. Neonatal HIE is a low-frequency, high-impact condition that poses specific challenges for implementation. These challenges varied and were driven by regional demographics, local resources and expertise, and existing collaboration (or lack thereof) between neonatology, pediatric neurology, and neuroradiology. Regional hospitals that had a large referral base and predominantly dealt with outlying hospitals had special challenges with developing educational tools and safety checklists for starting TH at referring hospitals and with transport. Others who did not transport infants from outlying hospitals focused on other PBPs. NICUs participating in the collaborative also varied in size.

**FIGURE 1**

An example of an Improvement Story Report Card. Documented are the specific PBPs, past and present practice, implications of change, and priority of efforts.

INICO, Internet Neonatal Intensive Care Quality; NNNS, NICU Network Neurobehavioral Scale; QIK, Quality Improvement Kit.
Smaller units had less frequent “HIE events” and thus faced the challenge of training staff to recognize infants, get familiar with equipment, and maintain skills by using simulation to overcome this hurdle. Despite these differences, all units successfully adapted all of the PBPs into a TH guideline. Extensive education efforts with multidisciplinary “champions” drove the implementation of these guidelines in each unit.

Clinically, the PBPs outlined in this improvement narrative are practical and can be implemented in units with diverse patient volumes and population demographics. A common theme in the success of this collaborative was a systematic approach to quality improvement, consistent educational programs, and sustained multidisciplinary leadership.

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REFERENCES


APPENDIX 1

### Arm Recoil

**Circle one**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Arms do not flex</td>
</tr>
<tr>
<td>2</td>
<td>Arms flex slowly, not always, not completely</td>
</tr>
<tr>
<td>3</td>
<td>Arms flex slowly, more completely</td>
</tr>
<tr>
<td>4</td>
<td>Arms flex quickly and completely</td>
</tr>
<tr>
<td>5</td>
<td>Arms difficult to extend, snap back injuriously</td>
</tr>
</tbody>
</table>

**Method:**
- Take both hands, quickly extend arms parallel to the body, count to three. Release. Repeat 3 times.

### Leg Recoil

**Circle one**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flexion</td>
</tr>
<tr>
<td>2</td>
<td>Incomplete or variable flexion</td>
</tr>
<tr>
<td>3</td>
<td>Complete but slow flexion</td>
</tr>
<tr>
<td>4</td>
<td>Complete fast flexion</td>
</tr>
<tr>
<td>5</td>
<td>Very difficult to extend, snap back injuriously</td>
</tr>
</tbody>
</table>

**Method:**
- Take both ankles in one hand, lift hips + knees. Quickly extend, release. Repeat 3 times.

### Head Lag

**Circle one**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Head drops &amp; stays back</td>
</tr>
<tr>
<td>2</td>
<td>Head in line with body</td>
</tr>
<tr>
<td>3</td>
<td>Head in front of body</td>
</tr>
<tr>
<td>4</td>
<td>Head above body</td>
</tr>
</tbody>
</table>

**Method:**
- Full infant towards sitting position by taking both wrists & support head slightly. Also note arm flexion.

### Ventral Suspension

**Circle one**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Back curved, head &amp; limbs hang straight</td>
</tr>
<tr>
<td>2</td>
<td>Back curved, head &amp; limbs slightly flexed</td>
</tr>
<tr>
<td>3</td>
<td>Back slightly curved, limbs flexed</td>
</tr>
<tr>
<td>4</td>
<td>Back straight, head &amp; limbs flexed</td>
</tr>
<tr>
<td>5</td>
<td>Back straight, head above body</td>
</tr>
</tbody>
</table>

**Method:**
- Hold infant in ventral suspension. Observe back, flexion of limbs, and relation of head to trunk. If it looks different, USE WHT.

**Movement**
- Normal (symmetrical, intermittent, alternating)
- Abnormal
  - No movement
  - Frequent startles
  - Tremors
  - Continuous movement
  - Fitting, toe flexion
  - Seizures

**Reflexes**
- Normal
  - Absent
  - Exaggerated

**Suck**
- Normal
- Absent
- Weak

**Grapes/plantar**
- Normal
- Absent
- Exaggerated

**Moro**
- Normal
- Absent
- Exaggerated
- Incomplete

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**APPENDIX 1**

Continued
**Therapeutic Hypothermia Program**

**CLINICAL PRESENTATION CHECKLIST**

- **H*** is now offering therapeutic hypothermia, a new therapy involving whole body cooling to 33.5°C for 72 hours. Recent studies have shown that when therapeutic hypothermia is initiated within 6 hours of birth, the incidence of death or severe disability is reduced. If a newborn is suspected of having neonatal encephalopathy, call 1-800-*** (1-800-***-****) immediately for a neonatal consultation. Avoid overheating any infant identified with encephalopathy by not using excessive blankets or a hat. Set servo temperature to 33.5°C.

1. Infant must meet **all** the following criteria:
   - ≥ 36 weeks gestation
   - Birth weight ≥ 1500 grams
   - if first-hour blood gas available (cord/ABG/CBG/VBG) pH ≤ 7.15 and base deficit ≥ 10
   - Able to begin cooling by 6 hours of age
   - No severe congenital anomaly
   - Not moribund and plans for full care

2. Infant must meet **either** of the following criteria:
   - First-hour blood gas (cord/ABG/CBG/VBG) pH ≤ 7 or base deficit ≥ 16
   - No blood gas available or first-hour gas pH 7.01-7.15 or base deficit 10-16

   **And Both:**
   - 10 min Apgar ≤ 5 or assisted ventilation at birth continued for ≥ 10 minutes
   - Acute perinatal event (for example, late/variable decels, cord prolapse, cord rupture, uterine rupture, maternal trauma/hemorrhage/cardio-respiratory arrest)

3. Infant must have **either** of the following:
   - Seizures (any medically witnessed reports, written or verbal, any type)

   **Or:**
   - Encephalopathy, with **at least one finding in at least three categories**:

<table>
<thead>
<tr>
<th>Category</th>
<th>Moderate Encephalopathy</th>
<th>Severe Encephalopathy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of consciousness</td>
<td>Lethargic</td>
<td>Stupor or coma</td>
</tr>
<tr>
<td>Spontaneous activity</td>
<td>Decreased activity</td>
<td>No activity</td>
</tr>
<tr>
<td>Posture</td>
<td>Distal flexion, complete extension</td>
<td>Decerebrate</td>
</tr>
<tr>
<td>Tone</td>
<td>Hypotonia (focal or general)</td>
<td>Flaccid</td>
</tr>
<tr>
<td>Primitive reflexes</td>
<td>Weak suck or incomplete Moro</td>
<td>Absent suck or Moro</td>
</tr>
<tr>
<td>Autonomic system</td>
<td>Constricted pupils, bradycardia, or periodic/irregular breathing</td>
<td>Deviated/dilated/nonreactive pupils, variable HR, or apnea</td>
</tr>
</tbody>
</table>

**APPENDIX 2**

Educational poster provided to referring hospitals with eligibility criteria and care reminders. ABG, arterial blood gas; CBG, capillary blood gas; decels, decelerations; HR, heart rate; Moro, Moro reflex.
APPENDIX 3

Detailed management guidelines for referring hospital implementation before transport. CBC, complete blood count; NNP, neonatal nurse practitioner; NRP, neonatal resuscitation program; temp, temperature; UAC/UVC, umbilical arterial catheter/umbilical venous catheter.

Step 1: Follow all necessary steps of NRP

- Stable Airway
- Adequate Breathing/Ventilation
- Good Circulation
- Normal glucose

Monitor Blood Glucose per STABLE guidelines (50-110 mg/dL)

Step 2: Make call to as soon as possible to discuss infants condition with the Neonatologist and initiate the transport process. (Include eligibility criteria)

Step 3: Prior to Transport Teams arrival: The priority is to stabilize the baby and avoid hyperthermia. Closely monitor temp. every 5 minutes. *Goal skin temp is 35-36 C. If skin temp. is less than 35 C, an external heat source may be used, making sure the infant temp. probe is secure and the servo temp is 35 C.

Step 4: Secure IV access: UAC/UVC or peripheral if unable to place central lines.

Step 5: Obtain Lab Work:
- Blood Gas
- Lactic Acid
- Glucose
- CBC with differential
- Blood Culture if indicated
- X-ray of chest and abdomen (available for NNP to view)

Step 6: Gather supplies
- Normal Saline (for flushes and boluses)
- 30 ml and 60 ml syringes
- Bags of ice
- Copy of Mom’s chart

Step 7: Ensure there is adequate personnel available
- One RN assigned to the infant to assist transport team.
- Respiratory Therapist
- X-ray and Labs will need to run quickly if at all possible

HIE infants are critically ill. Our goal is to stabilize the infant, initiate active cooling, and transport the baby as quickly as possible back to ****.
Optimizing Therapeutic Hypothermia for Neonatal Encephalopathy
Steven L. Olsen, Mitchell DeJonge, Alex Kline, Ellina Liptsen, Dongli Song, Betsi Anderson and Amit Mathur

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http://pediatrics.aappublications.org/content/early/2013/01/02/peds.2012-0891