<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>05/26</td>
<td>Evidence-based Guidelines for the Management of Large Hemispheric Infarction</td>
</tr>
<tr>
<td>06/23</td>
<td>Critical Care Management of Patients Following Aneurysmal Subarachnoid Hemorrhage</td>
</tr>
<tr>
<td>07/28</td>
<td>Guidelines for the Management of Spontaneous Intracerebral Hemorrhage</td>
</tr>
<tr>
<td>08/25</td>
<td>Determining Brain Death in Adults</td>
</tr>
<tr>
<td>09/22</td>
<td>Palliative and End-of-Life Care in Stroke: A Statement for Healthcare Professionals</td>
</tr>
<tr>
<td>10/27</td>
<td>Guideline for Reversal of Antithrombotics in Intracranial Hemorrhage</td>
</tr>
<tr>
<td>11/24</td>
<td>Guidelines for the Evaluation and Management of Status Epilepticus</td>
</tr>
<tr>
<td>12/22</td>
<td>Consensus Summary Statement of the International Multidisciplinary Consensus Conference on Multimodality Monitoring in Neurocritical snip Care</td>
</tr>
<tr>
<td>01/26</td>
<td>Guidelines for the Prevention and Management of Pain, Agitation/Sedation, Delirium, Immobility, and Sleep Disruption in Adult Patients in the ICU</td>
</tr>
<tr>
<td></td>
<td>Mechanical Ventilation in Adult Patients with Acute Respiratory Distress Syndrome</td>
</tr>
<tr>
<td>-</td>
<td>Appropriate Use of Bedside General and Cardiac Ultrasonography in the Evaluation of Critically Ill Patients: Part I and II</td>
</tr>
<tr>
<td>-</td>
<td>Insulin Infusion for the Management of Hyperglycemia</td>
</tr>
</tbody>
</table>
Evidence-Based Guidelines for the Management of Large Hemispheric Infarction

A Statement for Health Care Professionals from the Neurocritical Care Society and the German Society for Neuro-Intensive Care and Emergency Medicine

Michel T. Torrey · Julian Bisd · Denise H. Rhoney · Fred Rincon · Dimitri Staykov · Arun P. Amar · Panayiotis N. Varelas · Eric Jüttler · DalWai Olson · Hagen B. Huttner · Klaus Zweckerger · Kevin N. Sheth · Christian Dohmen · Ansgar M. Brambrink · Stephan A. Mayer · Osama O. Zaidat · Werner Hacke · Stefan Schwab

Published online: 21 January 2015

© All content, design, text and other materials are copyrighted by the Neurocritical Care Society (NCS). All rights reserved. Issued by the American Heart Association/American Stroke Association. The American Association of Neurological Surgeons (AANS) and the Congress of Neurological Surgeons (CNS) endorse the educational content of this scientific statement 2015

Abstract Large hemispheric infarction (LHI), also known as malignant middle cerebral infarction, is a devastating disease associated with significant disability and mortality. Clinicians and family members are often faced with a paucity of high quality clinical data as they attempt to determine the most appropriate course of treatment for patients with LHI, and current stroke guidelines do not provide a detailed approach regarding the day-to-day management of these complicated patients. To address this need, the Neurocritical Care Society organized an international multidisciplinary consensus conference on the critical care management of LHI. Experts from

M. T. Torrey
Cerebrovascular and Neurocritical Care Division, Department of Neurology and Neurosurgery, The Ohio State University Wexner Medical Center Comprehensive Stroke Center, 385 W. 12th Avenue, 7th Floor, Columbus, OH 43210, USA
e-mail: micheltorrey@osumc.edu

J. Bisd
Department of Neurology, University of Heidelberg, Im Neuenheimer Feld 400, 69120 Heidelberg, Germany
e-mail: julian.bisd@med.uni-heidelberg.de

D. H. Rhoney
Division of Practice Advancement and Clinical Education, UNC School of Pharmacy, 115 Heat Hand, Campus Box 7574, Chapel Hill, NC 27599-7574, USA
e-mail: dhrhoney@unc.edu

F. Rincon
Division of Critical Care and Neurotrauma, Department of Neurosurgery, Thomas Jefferson University, 900 Walnut Street, 3rd Floor, Philadelphia, PA 19107, USA
e-mail: francinorincon@jefferson.edu

D. Staykov
Department of Neurology, University of Erlangen-Nuremberg, Schwabachstraße 6, 91054 Erlangen, Germany
e-mail: dimirestaykov@uk-erlangen.de

A. P. Amar
Department of Neurosurgery, University of Southern California, 1200 North State Street Suite 3500, Los Angeles, CA 90083, USA
e-mail: amar@ucla.edu

P. N. Varelas
Neurocritical Care Division, Henry Ford Hospital, 2790 West Grand Boulevard, Detroit, MI 48202, USA
e-mail: varelas@neuros.fh.edu

E. Jüttler
Department of Neurology, Otto-von-Guericke-University, Münchner Strasse 2, 39120 Magdeburg, Germany
e-mail: eric.juettler@ovgu.de

D. Olson
University of Texas Southwestern, 5321 Harry Hines Blvd., Dallas, TX 75390-8858, USA
e-mail: dalwai.olson@utsouthwestern.edu

H. B. Huttner
Department of Neurology, University of Erlangen-Nuremberg, Schwabachalage 6, 91054 Erlangen, Germany
e-mail: hagen.huttner@uk-erlangen.de

© Springer
DEFINITION

ischemic stroke affecting total or subtotal territory of the MCA
involving basal ganglia at least partially
+/- involvement of adjacent territories (i.e., ACA or PCA)

Malignant MCA Infarction

- Typical clinical symptoms
- Uniform course
- Ending in herniation

Current guidelines offer limited discussion

AHA

NCS

German Society for NIC & EM

Clinical question → Assess quality → Develop recommendations

- Very low
- Low
- Mod
- High

- Strong
- Weak
<table>
<thead>
<tr>
<th>AIRWAY MANAGEMENT</th>
<th>ICU MANAGEMENT</th>
<th>ICP CRISIS</th>
<th>PREDICTING ICP CRISIS</th>
<th>SURGICAL MANAGEMENT</th>
<th>ETHICAL CONSIDERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the indications for intubation and extubation in LHI?</td>
<td>How should glucose be controlled in LHI patients?</td>
<td>Does hyperventilation effectively treat increased ICP in LHI?</td>
<td>Can neuroimaging predict neuro deterioration / malignant course after LHI?</td>
<td>Should DHC be offered to patients with DHI?</td>
<td>Is the reduction of mortality after DHC achieved at the expense of functional dependency?</td>
</tr>
<tr>
<td></td>
<td>What is the optimal Hb level in LHI patients?</td>
<td>Do steroids effectively reduce brain edema in LHI?</td>
<td>What is the value of TCD / TCCS for prediction of malignant course after LHI?</td>
<td>What are the selection criteria for DHC in LHI?</td>
<td>Is mRS score of 4 considered a desirable outcome after LHI?</td>
</tr>
<tr>
<td></td>
<td>Should analgesia / sedation be administered?</td>
<td>Do barbiturates effectively treat brain edema in LHI?</td>
<td>Can evoked potentials be used to predict malignant course after LHI?</td>
<td>What is the optimal timing ans size for DHC?</td>
<td>Is survival after LHI associated with a good QoL?</td>
</tr>
<tr>
<td></td>
<td>If with high thromboembolic risk, when should anticoagulation be initiated?</td>
<td>Does hypothermia or normothermia have any role in management of brain edema after LHJI?</td>
<td>Can EEG predict a malignant course after LHI?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>What is the optimal head position in patients with LHI?</td>
<td>Is there a utility for cEEG monitoring in LHI?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Does osmotic therapy effectively treat brain edema and improve outcome?</td>
<td>Can invasive MMM predict malignant course after LHI?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>What are the potential complications associated with the use of these agents?</td>
<td>What is the value of MMM in preventing secondary complications after LHI?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GI ISSUES</th>
</tr>
</thead>
<tbody>
<tr>
<td>How should dysphagia be assessed in LHI patients?</td>
</tr>
<tr>
<td>When should LHI patients receive an NGT? A PEG?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PREDICTING ICP CRISIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can neuroimaging predict neuro deterioration / malignant course after LHI?</td>
</tr>
<tr>
<td>What is the value of TCD / TCCS for prediction of malignant course after LHI?</td>
</tr>
<tr>
<td>Can evoked potentials be used to predict malignant course after LHI?</td>
</tr>
<tr>
<td>Can EEG predict a malignant course after LHI?</td>
</tr>
<tr>
<td>Is there a utility for cEEG monitoring in LHI?</td>
</tr>
<tr>
<td>Can invasive MMM predict malignant course after LHI?</td>
</tr>
<tr>
<td>What is the value of MMM in preventing secondary complications after LHI?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SURGICAL MANAGEMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Should DHC be offered to patients with DHI?</td>
</tr>
<tr>
<td>What are the selection criteria for DHC in LHI?</td>
</tr>
<tr>
<td>What is the optimal timing ans size for DHC?</td>
</tr>
<tr>
<td>Should age and hemispheric dominance play a role in the decision to offer DHC to LHI patients?</td>
</tr>
<tr>
<td>Should temporal lobectomy or duroplasty be offered as an adjunct therapy to DHC?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ETHICAL CONSIDERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the reduction of mortality after DHC achieved at the expense of functional dependency?</td>
</tr>
<tr>
<td>Is mRS score of 4 considered a desirable outcome after LHI?</td>
</tr>
<tr>
<td>Is survival after LHI associated with a good QoL?</td>
</tr>
<tr>
<td>AIRWAY MANAGEMENT</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>What are the indications for intubation and extubation in LHI?</td>
</tr>
<tr>
<td>What is the best timing for tracheostomy in LHI?</td>
</tr>
<tr>
<td>Should analgesia / sedation be administered in LHI?</td>
</tr>
<tr>
<td>Which agents should be used?</td>
</tr>
<tr>
<td>Are daily wake-up trials recommended?</td>
</tr>
<tr>
<td>GI ISSUES</td>
</tr>
<tr>
<td>How should dysphagia be assessed in LHI patients?</td>
</tr>
<tr>
<td>When should LHI patients receive an NGT? A PEG?</td>
</tr>
</tbody>
</table>
AIRWAY MANAGEMENT

What are the indications for intubation and extubation in LHI?

What is the best timing for tracheostomy in LHI?

Should analgesia / sedation be administered in LHI? Which agents should be used?

Are daily wake-up trials recommended?

GI ISSUES

How should dysphagia be assessed in LHI patients?

When should LHI patients receive an NGT? A PEG?
Airway Management

indications for intubation in LHI?

Issues:
- High use of ICU resources
- Poor prognosis despite ICU care
- Advanced options for treatment

only one prospective observational study intubation in LHI

- GCS <10
- Respiratory failure
- HTN
- >2/3 MCA

RECOMMEND: LHI patients with signs of respiratory insufficiency or neurological deterioration

Predicting successful extubation
- Impaired LOC + dysphagia
- High rate of failure
- Reintubation – ↑M&M

classic predictors unreliable, no prospective studies in LHI
small retrospective study (MCA stroke), GCS ≥8 (eye subscore 4) associated with successful extubation

RECOMMEND: Attempt extubation in LHI patients who meet criteria, (even if communication and cooperation cannot be established): successful SBT, absence of oropharyngeal saliva collections, no frequent suctioning, (+) cough reflex / tube intolerance, free of analgesia and sedation. (strong, very low)

CHECKLIST

- SBT
- Absence of oropharyngeal collections
- No frequent suctioning
- (+) cough reflex
- Off analgesia and sedation
Airway Management

timing for tracheostomy

**Early tracheostomy** not been studied in LHI

- Retrospective Study (mixed ICU)
  - Better outcome
  - Reduced vent duration
  - Reduced ICU stay / costs

- Recent RCT on early trach (mixed ICU)
  - Safe
  - Feasible
  - Reduced sedation needs

Predictors for tracheostomy suggested by retrospective studies for ICH

- Insufficient evidence in general or early tracheostomy in LHI specifically;
- Apply general customs for tracheostomy in ICU patients
- Reasonable to trach LHI patients between days 7 and 14

RECOMMEND: Tracheostomy should be considered in LHI patients failing extubation or in whom extubation is not feasible by 7–14 days from intubation. (weak, low)
Airway Management

Are daily wake-up trials recommended?

**PROs**
- Reduce ventilation duration
- Improve outcome

**CONs**
- Exhausted ICU compliance – risk for ICP increase
- Recent studies failed to confirm benefit
- Protocols not studied in LHI
- Sedation in TBI/SAH associated with potentially negative effects (rise in ICP, stress hormone levels)

**RECOMMEND**: Recommend against routine daily wake-up trials in LHI patients. Caution especially in patients prone to ICP crises. Neuromonitoring of ICP and CPP to guide sedation, abandon / postpone daily wake-up trials at signs of physiological compromise or discomfort. (strong, very low)
GI ISSUES

When should LHI patients receive a nasogastric tube? PEG tube?

Studies (timing of NGT) lacking

RECOMMEND: LHI with dysphagia should receive NGT as soon as possible. (weak, very low)

Predictors of need for PEG studied only in mixed populations
Prospective cohort study (stroke with dysphagia) = early enteral feeding in undernourished is beneficial, no time scale given

Base decision for PEG on:
- Impaired swallow
- Need for enteral feeding > 2 weeks
- Inability to tolerate NGT x 2 occasions

SUGGEST: Suggest that high NIHSS scores and persisting dysphagia on endoscopic swallowing should prompt discussion re PEG between weeks 1 and 3 of ICU stay. (weak, very low)

AIRWAY MANAGEMENT

What are the indications for intubation and extubation in LHI?

What is the best timing for tracheostomy in LHI?

Should analgesia / sedation be administered in LHI? Which agents should be used?

Are daily wake-up trials recommended?

GI ISSUES

How should dysphagia be assessed in LHI patients?

When should LHI patients receive an NGT? A PEG?
ICU MANAGEMENT

How should glucose be controlled in LHI patients?

What is the optimal Hb level in LHI patients?

How should DVT prophylaxis be administered?

If with high thromboembolic risk, when should anticoagulation be initiated?

What is the optimal BP?
**Glucose Control**

How should glucose be controlled in LHI patients?

**RECOMMEND:** Avoid hypo- and hyperglycemia. Target intermediate glycemic control (140-180mg/dL) in LHI patients. *(strong, very low)*

**RECOMMEND:** Avoid IV sugar solutions in LHI. *(strong, very low)*

---

**Clinical data on glucose control in LHI not been published**

- Retrospective Study *(mixed ICU)*
  - No benefit of tight control
  - Higher rates of hypoglycemia and mortality

- Recent SR & meta *(mixed ICU)*
  - No mortality benefit of intensive therapy
  - Increased hypoglycemia
ICU MANAGEMENT

Hemoglobin Control

What is the optimal hemoglobin level in LHI patients?

**RECOMMEND:** Maintain Hb 7 g/dL or higher in LHI. (strong, very low)

**CONSIDER:** Consider specific situations (planned surgery, hemodynamic status, cardiac ischemia, active significant bleeding, AV O2 extraction compromise) when determining ideal Hb. (weak, very low)

**CONSIDER:** Consider reduce blood sampling to decrease risk of anemia in LHI. (weak, very low)

---

**PROs**

- Anemia associated with worse outcomes (acute/subacute)
- Theoretically, optimizing O2 carrying capacity helps ischemia / oligemic brain
- TBI / SAH studies – benefits of transfusion suggested

**CONS**

- No evidence on effect on LHI
- Recent SR / meta – insufficient evidence (restrictive vs liberal) in NICU, LHI not included

---

**CHECKLIST**

- Maintain Hb 7 unless
- Planned surgery
- Hemodynamic status
- Cardiac ischemia
- Active bleeding
- AV O2 extraction compromise
ICU MANAGEMENT

Deep Venous Thrombosis Prophylaxis

How should DVT prophylaxis be administered to LHI patients?

- **Thigh-Length Stockings**
- **Below Knee Stockings**
- **IPC**
- **Heparin**

**CLOTS1 Trial**
- 11.4% D7-10
- 3.1% D25-30
- TLGS – skin ulcers, necrosis, leg ischemia
- BKS – more DVTs

**CLOTS3 Trial**
- ARR 3.6% (8.5% vs 12.1%)

Heparin prevents DVT in acute stroke, benefits outweigh risk

LMWH superior to UFH in several studies (not specific to LHI)

Small study in ICH – heparin safe within 2 days

**RECOMMEND:** Early mobilization to prevent DVT in hemodynamically stable LHI patients with no evidence of increased ICP. (strong, very low)

**RECOMMEND:** DVT prophylaxis for all LHI patients upon admission to ICU and for duration of immobilization. (strong, very low)

**RECOMMEND:** Use IPC for DVT prophylaxis. (strong, moderate)

**RECOMMEND:** Use LMWH for DVT prophylaxis. (strong, low)

**RECOMMEND:** Against use of compression stockings for DVT prophylaxis. (strong, moderate)
ICU MANAGEMENT

How should glucose be controlled in LHI patients?

What is the optimal Hb level in LHI patients?

How should DVT prophylaxis be administered?

If with high thromboembolic risk, when should anticoagulation be initiated?

What is the optimal BP?

Anticoagulation

<table>
<thead>
<tr>
<th>LHI</th>
<th>Afib</th>
<th>Prosth Valve</th>
<th>Cardiac Thrombus</th>
</tr>
</thead>
</table>

No studies in LHI, extrapolate from general AIS and ICH populations.

HAEST Study

- Ischemic stroke + Afib
- Stroke recurrence 8.5% w/in 14d in spite LMWH Px

Prosthetic valves, with ICH and AC withheld → thromboembolism occurred in 3% during 1\textsuperscript{st} 30 days, none during 1\textsuperscript{st} 15 days. ICH guidelines → range from 2d to 4wks.

When to restart in LHI:

- Restart after 2-4 wks
- *extraordinarily high risk*, earlier initiation (modest aPTT goal)
- *bleeding risk*, aspirin is alternative

SUGGEST: Restart oral anticoagulation 2-4 wks after LHI in patients at high thromboembolic risk. (weak, very low)

SUGGEST: Earlier reinitiation of oral AC should be based on clinical risk assessment and additional diagnostic tests (prosthetic valve, acute DVT/PE, TEE with intracardiac thrombus). (weak, very low)

SUGGEST: Use aspirin during period of no anticoagulation in LHI with AFib or increased thromboembolic risk, provided surgery not imminent. (weak, very low)
ICU MANAGEMENT

Blood Pressure Management

What is the optimal blood pressure in LHI patients?

- **SBP goals**: MAP >85 reasonable in AIS without hemorrhagic transformation.
- **SBP goals**: SBP <220mm Hg.

Avoid excessive hypotension after LHI

- BP Variability
  - Infarct expansion
  - Clinical deterioration
  - Worse outcomes, mortality

Attention to BP in acute LHI, e.g. during sedation, intubation or surgery.

RECOMMEND: Follow BP management guidelines for ischemic stroke in general. Maintain MAP >85, lower SBP to <220 mm Hg. (strong, low quality)

SUGGEST: Avoid BP variability, especially early LHI. (weak, low)
ICP CRISIS

Does hyperventilation effectively treat increased ICP in LHI?

Do steroids effectively reduce brain edema in LHI?

Do barbiturates effectively treat brain edema in LHI?

Does hypothermia or normothermia have any role in management of brain edema after LHI?

What is the optimal head position in patients with LHI?

Does osmotic therapy effectively treat brain edema and improve outcome?

What are the potential complications associated with the use of these agents?
ICP CRISIS

Steroid Therapy

Do steroids effectively reduce brain edema in LHI?

CONCLUSION: no benefit (morbidity or mortality) following stroke

RECOMMEND: Recommend against using steroids for brain edema in LHI. (strong, low)

Cochrane Group (acute stroke)

- Reviewed by Cochrane group
- Outcome: death 1y no difference (OR 0.97; 95% CI 0.57-1.34)
- Only 1/7 reported nonfatal adverse events
  - GI bleeding
  - Hyperglycemia
  - Infection in 10%

RCT (steroid in LHI)

- (included in above review)
- 1112 patients, placebo vs high-dose dexta within 48h
- No difference (death day 21 / neurological outcome)
ICP CRISIS

Temperature Control

Role of hypothermia or normothermia?

No RCTs addressing role of hypo/normothermia in LHI.

Some Studies

- Safety / feasibility of hypothermia in AIS, even with tPA
- Common S/E: hypotension, hematologic, infections
- Hypothermia significantly reduces ICP in LHI, not as effective as DHC
- Combined approach?

Concerns:
- Rebound inc in ICP (rewarming)
- PNA
- Coagulopathy

Further studies required to identify optimal target temperature and cooling duration.

SUGGEST: Consider hypothermia as treatment option in patients who are not eligible for surgical intervention. (weak, low)

SUGGEST: If considered, target 33-36°C for duration of 24-72h. (weak, low)

SUGGEST: Maintain normal core body temperature. (weak, very low)
ICP CRISIS

Does hyperventilation effectively treat increased ICP in LHI?

Do steroids effectively reduce brain edema in LHI?

Do barbiturates effectively treat brain edema in LHI?

Does hypothermia or normothermia have any role in management of brain edema after LHI?

What is the optimal head position in patients with LHI?

Does osmotic therapy effectively treat brain edema and improve outcome?

What are the potential complications associated with the use of these agents?

**SUGGEST:** Suggest horizontal position in most patients with LHI. In patients with increased ICP, suggest 30° backrest elevation. (weak, very low)

**ICP CRISIS**

**Head Position**

Optimal head position

<table>
<thead>
<tr>
<th>PROs</th>
<th>CONs</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Assist venous drainage</td>
<td>• May compromise CPP (&gt;45 °)</td>
</tr>
<tr>
<td>• Prevent ICP elevation</td>
<td></td>
</tr>
</tbody>
</table>

No RCTs to show benefit.

**One Observational Study**

- 15° vs 30° and return to 0°
- Record ICP, MAP, CPP, MCA peak MFV

**HORIZONTAL**

- CPP maximal
- ICP highest
- Risk of aspiration

**30 DEGREES**

- CPP / MAP decreased
- ICP decreased
PREDICTING ICP CRISIS

Can neuroimaging predict neuro deterioration / malignant course after LHI?

What is the value of TCD / TCCS for prediction of malignant course after LHI?

Can evoked potentials be used to predict malignant course after LHI?

Can EEG predict a malignant course after LHI?

Is there a utility for cEEG monitoring in LHI?

Can invasive MMM predict malignant course after LHI?

What is the value of MMM in preventing secondary complications after LHI?
### PREDICTING ICP CRISIS

#### Neuroimaging by CT and MRI

Can CT / MRI predict “malignant” course after LHI?

Nine observational and four case control studies (CT in LHI prognostication), **predictor variables** identified:

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYPO DENSITY &gt;50% MCA</td>
<td>85% PPV for fatal outcome, Sn 61% Sp 94%</td>
</tr>
<tr>
<td>Additional Territories involved</td>
<td>Associated with fatal brain edema</td>
</tr>
<tr>
<td>Carotid T occlusion (angi)</td>
<td>47% PPV for fatal outcome, NPV 85%, Sn 53% Sp 83%</td>
</tr>
<tr>
<td>Infarct Volume &gt;220mL</td>
<td>Predictive of brain edema and herniation</td>
</tr>
<tr>
<td>MLS &gt;3.9mm</td>
<td>Predictive of malignant infarction</td>
</tr>
</tbody>
</table>

- Poor collateral flow
- Lack of recanalization
- Distal ICA / prox MCA occlusion

**MRI-based prognostication – 7 observational, 6 retrospective, 1 prospective**

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADC &lt;80% + vol &gt;82cc within 6h</td>
<td>ADC &lt;80% (compared to contralateral) and volume &gt;82cc within 6h of symptoms onset predictive of LHI, Sn 87% Sp 91%</td>
</tr>
<tr>
<td>DWI volume</td>
<td>Volume on DWI predictive, accuracy varied depending on cutoff used &gt;82mLs 145ml vs &gt;177 mL &gt;145mL more likely to develop malignant edema requiring DHC</td>
</tr>
</tbody>
</table>

**RECOMMEND:** Use early changes on CT/MRI to predict malignant edema after LHI. (strong, low)
PREDICTING ICP CRISIS

Can neuroimaging predict neuro deterioration / malignant course after LHI?

What is the value of TCD / TCCS for prediction of malignant course after LHI?

Can evoked potentials be used to predict malignant course after LHI?

Can EEG predict a malignant course after LHI?

Is there a utility for cEEG monitoring in LHI?

Can invasive MMM predict malignant course after LHI?

What is the value of MMM in preventing secondary complications after LHI?

PREDICTING ICP CRISIS

Neuroimaging by CT and MRI

Can CT / MRI predict “malignant” course after LHI?

Nine observational and four case control studies (CT in LHI prognostication), predictor variables identified:

- Hypodensity >50% MCA
- Infarct volume >220mL
- Poor collateral flow
- Lack of recanalization
- Carotid T occlusion
- Distal ICA / prox MCA occlusion
- Involvement of ACA / PCA
- MLS >3.9 mm

MRI-based prognostication – 7 observational, 6 retrospective, 1 prospective

- ADC <80% + volume >82cc within 6h
- DWI volume >82 mL / >145 mL / >177 mL

RECOMMEND: Use early changes on CT/MRI to predict malignant edema after LHI. (strong, low)
SURGICAL MANAGEMENT

Should DHC be offered to patients with DHI?

What are the selection criteria for DHC in LHI?

What is the optimal timing and size for DHC?

Should age and hemispheric dominance play a role in the decision to offer DHC to LHI patients?

Should temporal lobectomy or duroplasty be offered as an adjunct therapy to DHC?
Surgical Management

**OUTCOME**
Outcome poor even with optimal **medical** management

Surgical Scarcella first described the operative approach 60y ago
DHC advocated as life-saving intervention

**OBSERVATIONAL STUDIES**
Observational studies, systematic reviews, clinical trial

**WHAT IS THE OPTIMAL TIMING AND SIZE FOR DHC?**
As of 2007 – 5 prospective RCTs reported

HeaDDFIRST
DECIMAL
DESTINY
HAMLET

Pooled analysis of 3 European trials
Surgical Management

As of 2007 – 5 prospective RCTs reported

Pooled analysis demonstrated benefits of DHC in LHI
all patients <60y, NIHSS >16, randomized within 48h
Survival >doubled (29% to 78%)
ARR 49%, NNT of 2

No significant improvement in functional outcome (mRS 0-3 vs 4-6)
Dec mortality offset by increased disability – DHC prolongs poor QoL?

RECOMMEND: Recommend DHC as potential therapy to improve survival after LHI, regardless of patient age. (strong, high)
SURGICAL MANAGEMENT

Surgical Management
As of 2007 – 5 prospective RCTs reported

HeaDDFIRST
Hemicraniectomy and durotomy upon deterioration from infarction-related swelling trial
Phase 2 feasibility study
Nonsignificant reduction in mortality (46% to 27%)

DECIMAL
Decompressive Craniectomy in Malignant MCA Infarct

DESTINY
Decompressive Surgery for the Treatment of Malignant Infarction of the MCA Trial

HAMLET
Hemicraniectomy after MCA Infarction with Life-threatening Edema Trial

Pooled analysis demonstrated benefits of DHC in LHI

<60y/o
NIHSS >16
Within 48h of symptom onset

RECOMMEND: Recommend DHC as potential therapy to improve survival after LHI, regardless of patient age. (strong, high)
SURGICAL MANAGEMENT

Surgical Management

Optimal timing uncertain
Large Hemispheric Infarction

- Clinical predictors (NIHSS)
- Radiographic (location of thrombus, CT/MRI)
- Lab tests (S100B levels)

RECOMMEND: Perform DHC within 24-48h of symptom onset and prior to any herniation symptoms. (strong, moderate)

Early vs late decompression (<24h vs >24h) studies
Some show decreased mortality, reduced herniation, decreased time in ICU, other shows increased disability

PROPHYLACTIC

- Operate as soon as diagnosis of MCA infarction is made
- DECIMAL and DESTINY – DHC within 24h, mortality reduced, neurologic outcome improved 6 and 12 mos after

REACTIVE

- Wait for neurologic deterioration / brainstem herniation
- worse clinical outcome and increased mortality rate in patients with clinical signs of herniation prior to DHC

Brain Herniation

Clinical predictors (NIHSS)
Radiographic (location of thrombus, CT/MRI)
Lab tests (S100B levels)

Clinical predictors (NIHSS)
Radiographic (location of thrombus, CT/MRI)
Lab tests (S100B levels)

Clinical predictors (NIHSS)
Radiographic (location of thrombus, CT/MRI)
Lab tests (S100B levels)
Surgical Management

Size of DHC

**Suboptimal DHC** (<12cm) linked to increased cerebral complications, decreased survival rate

*most* studies – *at least* 12cm.

*some* studies –
  >13-14cm in diameter, or even including SSS resection of temporal muscle

**Other surgical decisions:**
  - timing of cranioplasty
  - storage of bone flap
  - replacement with autologous vs synthetic flap

**RECOMMEND:** Recommend size of 12cm as absolute minimum for DHC. Larger sizes (14-16cm) seem to be associated with better outcomes. *(strong, moderate)*
**Surgical Management**

**AGE:**

Offer to young (<60y) patients with LHI

DHC improved survival but not improved function, in >/=60y

**DESTINY II**

RCT, >60y with LHI
Decreased mortality (70%-33%)
32% and 28% = mRS4 and 5
7% = mRS 3

**RECOMMEND:** Consider patients and family wishes in patients older than 60y, since DHC can reduce mortality rate but with a higher likelihood of being severely disabled. (strong, moderate)
**Surgical Management**

**DOMINANCE:**

LHI of dominant hemisphere – severe residual aphasia regarded as unacceptable outcome

<table>
<thead>
<tr>
<th>One Small Study</th>
<th>LHI dominant not associated with worse functional outcomes or QoL</th>
</tr>
</thead>
<tbody>
<tr>
<td>GUPTA Systematic Review</td>
<td>stronger evidence</td>
</tr>
<tr>
<td>Pooled Analysis</td>
<td>stroke laterality did not influence functional outcome</td>
</tr>
</tbody>
</table>

**RECOMMEND:** There is insufficient data to recommend against DHC based on hemispheric dominance. (strong, low)
ETHICAL CONSIDERATIONS

Is the reduction of mortality after DHC achieved at the expense of functional dependency?

Is mRS score of 4 considered a desirable outcome after LHI?

Is survival after LHI associated with a good QoL?
<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>05/26</td>
<td>Evidence-based Guidelines for the Management of Large Hemispheric Infarction</td>
</tr>
<tr>
<td>06/23</td>
<td>Critical Care Management of Patients Following Aneurysmal Subarachnoid Hemorrhage</td>
</tr>
<tr>
<td>07/28</td>
<td>Guidelines for the Management of Spontaneous Intracerebral Hemorrhage</td>
</tr>
<tr>
<td>08/25</td>
<td>Determining Brain Death in Adults</td>
</tr>
<tr>
<td>09/22</td>
<td>Palliative and End-of-Life Care in Stroke: A Statement for Healthcare Professionals</td>
</tr>
<tr>
<td>10/27</td>
<td>Guideline for Reversal of Antithrombotics in Intracranial Hemorrhage</td>
</tr>
<tr>
<td>11/24</td>
<td>Guidelines for the Evaluation and Management of Status Epilepticus</td>
</tr>
<tr>
<td>12/22</td>
<td>Consensus Summary Statement of the International Multidisciplinary Consensus Conference on Multimodality Monitoring in Neurocritical’snip Care</td>
</tr>
<tr>
<td>01/26</td>
<td>Guidelines for the Prevention and Management of Pain, Agitation/Sedation, Delirium, Immobility, and Sleep Disruption in Adult Patients in the ICU</td>
</tr>
<tr>
<td></td>
<td>Mechanical Ventilation in Adult Patients with Acute Respiratory Distress Syndrome</td>
</tr>
<tr>
<td></td>
<td>Appropriate Use of Bedside General and Cardiac Ultrasonography in the Evaluation of Critically Ill Patients: Part I and II</td>
</tr>
<tr>
<td></td>
<td>Insulin Infusion for the Management of Hyperglycemia</td>
</tr>
</tbody>
</table>
Critical Care Management of Patients Following Aneurysmal Subarachnoid Hemorrhage: Recommendations from the Neurocritical Care Society’s Multidisciplinary Consensus Conference

Michael N. Driinger · Thomas P. Black · J. Claude Humphill III · David Menon · Lori Shutler · Paul Yassa · Nicolai Bruder · F. Sander Connolly Jr. · Giuseppe Clarino · Daryl Green · David Mingli · Brian L. Hoh · Giuseppe Landolfi · Peter Le Roux · Alejandro Ravina · Erich Schmutzhard · Nino Stocchetti · Jose L. Suarez · Miriam Treiglari · Ming-Yuan Tseng · Marylyn D. L. Verguon · Stefan Wolf · Gregory Zipes

Published online: 20 July 2011 © Springer Science+Business Media, LLC 2011

Abstract Subarachnoid hemorrhage (SAH) is an acute neurovascular event which can have devastating effects on the central nervous system as well as a profound impact on several other organs. SAH patients are routinely admitted to an intensive care unit and are cared for by a multidisciplinary team. A lack of high quality data has led to numerous approaches to management and limited guidance on choosing among them. Existing guidelines emphasize risk factors, prevention, natural history, and prevention of rebleeding, but provide limited discussion of the complex critical care issues involved in the care of SAH patients. The Neurocritical Care Society organized an international, multidisciplinary consensus conference to address such topics. Experts from neurocritical care, neurosurgery, neurology, interventional neuroradiology, and neuroangiography from Europe and North America were recruited based on their publications and expertise. A jury of four experienced neurointensivists was selected for their experience in clinical investigations and development of practice guidelines. Recommendations were developed based on literature review using the GRADE system, discussions integrating the literature with the collective experience of the participants and critical review by an impartial jury. Recommendations were developed using the GRADE system. Emphasis was placed on the principle that
Malignant MCA Infarction

Assess quality

- Typical clinical symptoms
- Uniform course
- Ending in herniation

SBT
- Absence of oropharyngeal collections
- No frequent suctioning
- (+) cough reflex
- Off analgesia and sedation