MHIF Research Highlights: JANUARY 2019

Congratulations on First Enrollments!

• Dr. Daniel Melby and team – Congratulations on first enrollment in the VISITAG SURPOINT study!
• Dr. David Lin and Christine Majeski – Way to go on your FIRST IN THE WORLD enrollment for the Rhapsody study!

Featured MHIF Studies
Open for Enrollment and Referrals!

ACCUCINCH early feasibility in significant symptomatic MVR and LV remodeling
CONTACT: Sara Olson, 612-863-7601

XIENCE 90 for patients at high risk of bleeding who need coronary stents
CONTACT: Amy McMeans, 612-863-3895

VISITAG SURPOINT tag index-guided ablation for atrial fibrillation
CONTACT: Jacob Cohen, 612-863-6051

Mark Your Calendars

Time to Run… or volunteer!

MHIF is proud to sponsor the Valentine’s 5K with Twin Cities in Motion. Mark your calendar!
Sat., Feb. 9, Lake Nokomis!

Raising Awareness of Valvular Disease!

MHIF is hosting a second annual Mechanics of a Healthy Heart event for patients.
Thurs, Feb. 21, Golden Valley Country Club!

Sharing Great Research…

Dr. Jay Traverse published NHLBI-Sponsored postconditioning study in Circulation Research showing delayed benefit for STEMI patients!

Thanks Dr. Retu Sexana for sharing important updates on women’s heart health for the Twin Cities in Motion Podcast!
Head Up CPR
February 4, 2019

Johanna Moore MD, MSc
Department of Emergency Medicine
Hennepin Healthcare

Assistant Professor
University of Minnesota Medical School

Financial Disclosures

• No COI to disclose
• Co-PI on NIH NHLBI SBIR grant
This is your brain...on CPR. What do you want?

Cerebral Perfusion Pressure = Mean Arterial Pressure - Intracranial Pressure
ACD: Active Compression Decompression
ITD: Impedance Threshold Device

Head Up CPR: Take Home Points

- Animal studies have shown that Head Up CPR as compared to flat CPR:
  - Increases cerebral perfusion pressure
  - Increases cerebral blood flow
  - Increases coronary perfusion pressure
  - Decreases Intracranial Pressure
- Human cadaver studies have shown that Head Up CPR as compared to flat CPR:
  - Increases cerebral perfusion pressure and decreases intracranial pressure
- Head Up CPR used as a part of new bundles of care has resulted in increased hospital to admission rates

Why do we need to improve CPR?

<table>
<thead>
<tr>
<th>Survival metric</th>
<th>Hennepin EMS (n = 357)</th>
<th>Minnesota (n = 2,216)</th>
<th>National (n = 76,215)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Survival (all rhythms)</td>
<td>14.0% (50)</td>
<td>12.0% (267)</td>
<td>10.4% (7949)</td>
</tr>
<tr>
<td>Overall Survival with good brain function</td>
<td>9.8% (35)</td>
<td>9.7% (216)</td>
<td>8.4% (6392)</td>
</tr>
<tr>
<td>Utstein Bystander (shockable rhythm, witnessed, bystander CPR)</td>
<td>46.9% (32)</td>
<td>40.8% (184)</td>
<td>36.5% (4935)</td>
</tr>
</tbody>
</table>
Time Up After 23-25ish Minutes?


There Is No Silver Bullet

- There is not a single fix to improve outcomes
- We must build upon the chain of survival
  - Try to ensure patients get as many elements as possible
  - Build new promising therapies into the chain of survival
- Enhancing perfusion during CPR is optimal for all brains and hearts, regardless of etiology of arrest
Inspiration

Seoul, South Korea

What Position is best?

Head Down

Head Up

Flat
Head Up CPR: How Does It Work?

• Similar to the concept of elevating the head of a patient with a neurosurgical emergency
• Increases venous drainage from head, venous sinuses, and cervical paravertebral plexus
• Decreases “concussion with every compression” by mitigating pressure transduced up the vasculature to the head
• Ultimately improves cerebral blood flow, perfusion pressures
• Improves cardiac flow? Reduces pulmonary vascular resistance? Improves neuro outcomes?

Head Up CPR-First Study 2014

• 14 pigs were placed on a tilt table, underwent LUCAS+ITD CPR
• 5 min supine, 5 min Head Up, 5 min Head Down after 6 min of ventricular fibrillation
• An additional 8 pigs were measured at different angles of CPR
• Brain blood flow was measured in 8 pigs

Change of Position: Head Down

Change of Position: Head Up

Debaty et al., Resuscitation, 2015.

Head Up CPR: First Study

- Cerebral brain blood flow was 50% higher (0.19 ± 0.04 ml/min/g/tissue at 0° vs 0.27 ± 0.04 at 30° Head Up)

- Cerebral perfusion pressure was higher (19 ± 3 mmHg at 0° vs 35 ± 3 at 30° Head Up) (p < 0.001)

- Coronary perfusion pressure was higher (19 ± 2 mmHg at 0° vs 30 ± 3 at 30° Head Up) (p < 0.001)
Head Up CPR: Second Study

• Different body position
• Different CPR methods: ACD+ITD and standard
• Longer ventricular fibrillation time (8 min)
• 2 minutes flat, or “priming”
• Longer CPR time (22 min total)


Head Up CPR: Third Study

• Sought to replicate study 2, with brain blood flow Brain blood flow doubled at 15 min:

ACD+ITD Flat at \(0.21 \pm 0.04\) mg/mL/g tissue
ACD+ITD Head Up \(0.42 \pm 0.05\) mg/mL/g tissue \((p = 0.01)\)

\(0.19 \pm 0.04\) flat vs. \(0.27 \pm 0.04\) mg/mL/g tissue HUP with LUCAS+ITD at 5 minutes

Is There an Optimal Angle?

- VF left untreated for 8 minutes
- Animals were randomized to one of 6 combinations for 5 minute CPR intervals:
  
  \[
  \begin{array}{ll}
  20^\circ, 30^\circ, 40^\circ & 20^\circ, 40^\circ, 30^\circ \\
  30^\circ, 20^\circ, 40^\circ & 30^\circ, 40^\circ, 20^\circ \\
  40^\circ, 20^\circ, 30^\circ & 40^\circ, 30^\circ, 20^\circ \\
  \end{array}
  \]
- No difference in Cerebral Perfusion Pressure ($p = 0.52$) in 13 pigs:
  
  \[
  \begin{array}{l}
  20^\circ, 36 \pm 19 \\
  30^\circ, 42 \pm 21 \\
  40^\circ, 44 \pm 27 \\
  \end{array}
  \]

CerPP was higher if 40° HUP was performed during the last 5 minutes of the resuscitation (81 mmHg ± 16), versus 20° HUP and 30° HUP combined (41 mmHg ± 19, p = 0.007)

Sequence Study

- 13 animals studied: 7 with 20°, 30°, 40° sequence and 6 with 40°, 30°, 20°
- After 15 minutes of CPR, CerPP were higher with the 20°, 30°, 40° sequence: 54 ± 21 mmHg versus 26 ± 18 mmHg (p = 0.03)

<table>
<thead>
<tr>
<th>Sequence</th>
<th>Cerebral Perfusion Pressure, mmHg ± SD</th>
<th>Coronary Perfusion Pressure, mmHg ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>20°, 30°, 40°</td>
<td>54 ± 21</td>
<td>45 ± 20</td>
</tr>
<tr>
<td>40°, 30°, 20°</td>
<td>26 ± 18 *</td>
<td>25 ± 16</td>
</tr>
</tbody>
</table>

* p = 0.03

Moore et al, AHA-ReSS, 2018
Sequence Study

Cerebral Perfusion Pressure

Coronary Perfusion Pressure

Mean Aortic Pressure

Mean Intracranial Pressure

Moore et al, AHA-ReSS, 2018
How Fast to Raise The Head?

![Graph showing cerebral perfusion pressure (mmHg) over CPR duration]

Rojas-Salvador C, et al. NAEMSP 2019

You’re Doing It Wrong…

- All animal studies have shown that Head Up CPR is reliant on technology that augments perfusion during CPR such as LUCAS+ITD or ACD+ITD.
- Standard CPR does not provide good enough baseline perfusion to harness the effect of HUP CPR.
- It is hard to pump blood uphill.

Human Cadaver Head Up Studies

- Sought to replicate Head Up physiology in humans
- Studied 9 recently deceased human cadavers who had donated their bodies to science
- Bodies were never frozen. Airway, Vascular, Intracranial Access
- 2 minute epochs of standard, ACD+ITD CPR, ACD+ITD Head Up CPR

<table>
<thead>
<tr>
<th></th>
<th>S-CPR</th>
<th>ACD+ITD CPR</th>
<th>ACD+ITD HUP CPR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITP</td>
<td>-0.1±1</td>
<td>-5.0±2**</td>
<td>-5.7±2</td>
</tr>
<tr>
<td>MAP</td>
<td>7.8±4</td>
<td>5.2±3*</td>
<td>5±5</td>
</tr>
<tr>
<td>RA</td>
<td>9.0±2</td>
<td>8.7±3</td>
<td>9.9±5</td>
</tr>
<tr>
<td>ICP</td>
<td>0.8±2</td>
<td>0.7±3</td>
<td>-8.1±6**</td>
</tr>
<tr>
<td>CerPP</td>
<td>3.5±4</td>
<td>1.3±4.3*</td>
<td>11.3±5**</td>
</tr>
</tbody>
</table>

*** p<0.001; ** p<0.01; * p<0.05 vs the previous intervention


Why Rialto Fire Department sees heart attack survival rates 3 times above national average
Palm Beach County Florida
Head Up CPR Experience (2014-2016)
Paul E. Pepe, MD, MPH, Kenneth A. Scheppke, MD, Peter M. Antevy, MD

Protocol Changes in 2015
1) Ensure proper use of mechanical CPR
2) Apply O₂ but defer ventilation 6 mins;
3) Apply impedance threshold device;
4) Automated CPR
5) Raise the backboard 30° (head/torso up position).

Confirming the Clinical Safety and Feasibility of a Bundled Methodology to Improve Cardiopulmonary Resuscitation Involving a Head-Up/Torso-Up Chest Compression Technique
Paul E. Pepe, MD, MPH, MCCM, MACP, FAEMS; Kenneth A. Scheppke, MD; Peter M. Antevy, MD; Remie F. Crowe, PhD, NBEMT; Daniel Milstone, EMT-P; Charles C. Cyall, EMT-P; Craig Prusansky, EMT-P; Sebastian Garay, EMT-P; Richard Ellis, EMT-P; Raymond L. Fowler, MD, FACEP, FAEMS; Johanna C. Moore, MD, MPH

In Press
Critical Care Medical 2018
Overall Outcomes – Survival to Hospital Admission

<table>
<thead>
<tr>
<th>Resuscitation Rates</th>
<th>Before</th>
<th>After</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>17.9%</td>
<td>34.2%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>VF/VT</td>
<td>23.0%</td>
<td>44.4%</td>
<td>=0.001</td>
</tr>
<tr>
<td>Non-VF/VT</td>
<td>13.6%</td>
<td>30.9%</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>


2100 Cases from 2014-2016
Palm Beach County Outcomes: Survival to Hospital Admission

Figure 4. The raw number of patients resuscitated by emergency medical services teams who were successfully delivered to the emergency department alive with sustained circulation for the calendar years 2014, 2015 (the year of transition with inclusion of head-up cardiopulmonary resuscitation), and 2016, respectively.

Outcome improved across all subgroups while response intervals, indications for initiating CPR, and bystander CPR rates were unchanged

Wedge and towel

![Image of wedge and towel](image1.png)

Mechanical lift with sniffing position

![Image of mechanical lift](image2.png)
Body and LUCAS Slip Off
The “Do’s and Don’ts” of Head Up CPR

• Do’s
  1. Use circulatory adjuncts during CPR (ITD alone + standard CPR, automated CPR+ ITD, ACD+ITD)
  2. “Prime” the circuit before elevation (90-120 sec)
  3. Consider elevating the head and chest/shoulders only during CPR

• Don’ts
  1. Perform Head Up CPR with standard CPR alone
  2. Raise the head of the patient immediately while in arrest
  3. Avoid elevating the whole body over prolonged CPR effort
  4. Elevate at a high angle, then come down, there is a sequence effect


The Bundle of Care-Head Up CPR

<table>
<thead>
<tr>
<th>Electrical</th>
<th>Circulatory</th>
<th>Metabolic</th>
<th>Refractory Arrest</th>
<th>Post ROSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 4 minutes</td>
<td>4 to 10 (20?) minutes</td>
<td>10 (20?) to 60 minutes?</td>
<td>&gt;60 min, await ROSC post cath</td>
<td></td>
</tr>
</tbody>
</table>

Immediate High Quality CPR
Defibrillation
Head Up CPR
Epinephrine?

- High Quality CPR
- Defibrillation
- Head Up CPR
- Epinephrine?
- Anti-arrhythmics

- High Quality CPR
- eCPR <60 min
- Defibrillation
- Head Up CPR
- Additional pharmacologic agents

Continue eCPR
Cardiac Catheterization
Head Up CPR
Therapeutic Hypothermia
Maintain MAP (65? 80?) via pressors, fluids, active IPR therapy
Head Up Position?
Avoid hypoxia
Summary

1. Head Up CPR improves cerebral perfusion, and to a lesser degree, cardiac perfusion.
2. Findings of animal studies have been replicated in cadaver studies
3. Head Up CPR is used as parts of new bundles of care in a few sites throughout the country, with improved outcomes
4. Head Up CPR must be performed with circulatory adjuncts
5. Head Up CPR is a promising therapy to improve neurologic outcome after cardiac arrest
6. There is no silver bullet for cardiac arrest—many things must be performed correctly in the chain of survival for a good neurologic outcome!

References

References 2


- Moore JC, Segal N, Debaty G, Lurie KG. The “Do's and Don'ts” of Head Up CPR: Lessons Learned from the Animal Laboratory.” *Resuscitation*. August 2018; 129: e6-e7

- Moore JC, Salverda B, Lick M, Rojas-Salvador C, Debaty G, Segal N, Lurie KG. Controlled progressive elevation maximizes cerebral perfusion pressure during head up CPR in a swine model of cardiac arrest. Accepted for oral presentation at the AHA Resuscitation Science Symposium, November 2018, Chicago, IL.

References 3

- Pepe PE, Scheppke KA, Antevy PM, Coyle C, Millstone D, Prusansky C, Moore JC. Confirming the clinical safety and feasibility of a bundled methodology to improve cardiopulmonary resuscitation involving a head-up/torso-up chest compression technique. *Critical Care Medicine*. In Press.


- Rojas-Salvador C, Moore JC, Salverda B, Debaty G, Lick M, Lurie KG. Controlled fast head and thorax elevation improves cerebral perfusion pressure during active compression and decompression cardiopulmonary resuscitation with an impedance threshold device in a porcine model of cardiac arrest. Accepted for poster presentation at the NAEMSP Annual Meeting, 2019, Austin TX.