AAO NEW IDEAS FORUM

Cranial Compliance & CSF Mobility (Evidence-Based Measures)

Louisville, KY - 3/2012
Cranial Compliance & CSF Mobility
(Evidence Based Measures)

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Overview of This “New” Idea

• High profile, high impact topic – head trauma
• Important but controversial osteopathic approach – OCF
• Shift focus of prior research
• Employ state-of-art technology & methods
• Document impact on physiology
• Build on evolving evidence base
“High Profile – High Impact Topic”

Jan 11, 2012: Michelle Obama & Dr. Jill Biden announced JOINING FORCES @ Virginia Commonwealth University. AACOM joined AAMC leadership and member deans at the event.

Osteopathic medical college deans attending:

- Marc B. Hahn, DO – UNECOM
- Don N. Peska, DO – UNTHSC/TCOM
- Thomas A. Scandalis, DO – NYIT/NYCOM
- Anthony J. Silvagni, DO – Nova/SECOM
- Dixie Tooke-Rawlins, DO – EV/VCOM
- Kenneth J. Veit, DO, MBA – PCOM

All 26 COMs (+4 branches) signed pledge
Traumatic Brain Injury (TBI) – A “Joining Forces” Key Topic

Example: Indiana University School of Medicine

- "The IU School of Medicine has a focus on the neurosciences, which goes hand in hand with treatment for post-traumatic stress disorder and traumatic brain injury, two of the unique health care needs of veterans cited by the Joining Forces initiative." – Dean D. Craig Brater
Mild Traumatic Brain Injury - Concussion

Estimated Average Annual Number of TBI in the United States, 2002–2006

52,000 Deaths
275,000 Hospitalizations
1,365,000 Emergency Department Visits
???
Receiving Other Medical Care or No Care

Is there a role for OMT? Osteopathic focus on somatic dysfunction of head
Condition: Mild ↔ Severe

Mechanism of Injury → Pathophysiology

- Swelling
- Metabolites
- Bleeding

Body Attempts to Heal (Homeostatic Mechanisms)

- CSF-Venous Drainage
- Cranial Compliance
FUNCTIONAL GOALS OF INTRA-CRANIAL FLUIDS

- Deliver nutrition to brain tissue
- Transport nutrition in brain tissue
- Maintain water balance in brain tissue
- Optimize intra-cranial stroke energy for brain nutritional supply
- Distribute blood & CSF in brain under stress situations
- Evacuate wastes from brain tissue
Problem

Too Much Intracranial Fluid

Clinical Examples

- Traumatic brain injury
- Hydrocephalus
- Subarachnoid hemorrhage
- Strokes
- Hydrocephalus
- CNS infections

Symptoms:
- Headache
- Dizziness
- Nausea/Vomiting
- Lethargy
- Fatigue
- Sleep Disturbances
- Concentration & Memory Loss
- Irritability
- Visual Changes
Homeostatic Mechanisms

- Increase cranial sutural compliance
- Down-regulate CSF production by the choroid plexus
- Up-regulate absorption/drainage mechanisms via
  - Lymphatics (spinal nerves & CNI [cribriform plate])
  - Arachnoid granulations → Venous sinuses

Improved Symptoms & Resolution

- Traumatic brain injury
- Hydrocephalus
- Subarachnoid hemorrhage
- Strokes
- Hydrocephalus
- CNS infections

Compliance effective or reduced fluids
Measurements of Cranial Compliance & CSF Distribution of Intra-Cranial Stroke Volume

- TCDG (ΔP)
  - 3-5 ml of stroke volume - changeable component
  - 6-7 ml of stroke volume Depends on Vascular Resistance (Steady state blood flow)

Expanding of the skull (cranial compliance) CSF-movements inside skull and between skull and spinal cavities
# New Ideas (Forum): Switch Homeostatic Emphasis from the Container to the Fluid

## Old Approach

1. “Cranial bones move”
2. OMT corrects cranial SD (container)
3. We find “SD” & claim OMT removes it
4. They challenge 1-3 but if accept any, they say “no EBM that SD is clinically relevant”

## New Idea/Approach

1. Head trauma is a “container–fluid imbalance” problem
2. OMT/OCF has measurable effect on total fluid (CSF)
3. Evidence base now; underlying mechanism later
4. Oh & by the way … there is a measurable change in cranial compliance too
Treatment Options For Pathophysiology

- Traumatic brain injury
- Hydrocephalus
- Subarachnoid hemorrhage
- Strokes
- Hydrocephalus
- CNS infections

Rx for Container
- Surgical / Trephination
- Ventricular Shunt

Rx for Fluid
- Ventricular Shunt
- Medications

OMT

Fluid and Cranial Compliance Imbalance

Cranium with sutures
Homeostasis Overwhelmed in an Infant (Chronic)

Eg: Hydrocephalus & Shortened Life Span
Homeostasis Overwhelmed in an Adult (Chronic)

- Nausea/Vomiting
- Headache/Dizziness
- Lethargy/Fatigue
- Cognitive/Memory Loss
- Visual Changes
- Death

- Traumatic brain injury
- Hydrocephalus
- Subarachnoid hemorrhage
- Strokes
- Hydrocephalus
- CNS infections

- Fluid overwhelming compliance

- Fluid and Cranial Compliance Imbalance

- Cranium with sutures

- Death
Nausea/Vomiting
Headache/Dizziness
Lethargy/Fatigue
Cognitive/Memory Loss
Visual Changes
DEATH

Eg: Hydrocephalus & Shortened Life Span

Rx for Container
Surgical/Trephination
Ventricular Shunt
OMT

Rx for Fluid
Ventricular Shunt
Medications / OMT

Improved Symptoms & Resolution

+ Concentration
- Headache
+ Fatigue
+ Confusion

Compliance effective or reduced fluids
Fluid overwhelming compliance

Traumatic brain injury
Hydrocephalus
Subarachnoid hemorrhage
Strokes
Hydrocephalus
CNS infections

Fluid and Cranial Compliance Imbalance

Craniun with sutures chronic

Nausea/Vomiting
Headache/Dizziness
Lethargy/Fatigue
Cognitive/Memory Loss
Visual Changes
DEATH
That VooDO that You DO !?!

New Opportunity to dispel that opinion by . . .

- Documenting physiological changes made in vascular & CSF dynamics
  - Calculating CSF mobility ($\text{CSF}_{\text{mo}}$)
  - Calculating Cranial Compliance (CC)
- Documenting the OMT techniques we use (site, pressure, duration, etc)
Systems & Structures Responsible for Circulatory–Metabolic Supply of Brain Activity

Central Arterial Pressure

HEART ACTIVITY

Central Venous Pressure

Brain Activity

Intracranial Pressure

Brain Volume

Pulsations of Central Arterial Pressure

Pulsations of Central Venous Pressure

Brain Blood Flow & Nutrition Supply

Brain Cortex EEG - Correlates

Quality of Cognitive Brain Activity

FINAL FUNCTIONAL GOAL
Equipment & Finding TCD “Window”
Transcranial Doppler (TCD) Finding the Windows (Middle Cerebral Artery)

Adjust TCD power settings to identify exact site along the MCA bilaterally.
Bilateral Middle Cerebral Arteries on Transcranial Doppler
Initial Spectrum - baseline reading of subject

- Subject remains motionless with eyes closed for 1-2 minutes.
- No outside stimulation

Repeated at end of treatment to see if changed or not
EXAMPLE: Stookey Test – Subject breathes normally while examiner applies pressure (8lbs.) to the abdomen – This increases venous return and therefore increases both intra-cranial volume and pressure.
TCD/ REG Measurement Protocol --
Baseline Functions : OMT : Post-OMT Functions

Functional Tests to Physiologically Modulate Vascular Fluid Flow

- Frequency Spectrum (1 minute)
- Respiratory cessation (30+ seconds)
- 7 seconds cessation after inhalation
- 7 seconds cessation after exhalation
- Hyperventilation (20 seconds)
- Stookey test (20 seconds)
- Frequency Spectrum (1 minute)

Also Perform Cognitive Test (PASAT-3) Before & After
The significant waves in the spectrum analysis are shown here. The slow fluctuation and the primary cardiac wave are most important for the analysis. The respiratory wave will be used mainly for a reference point and the 2nd harmonic is not needed for the analysis.
Frank 11/10/2011
Pre-treatment:
Frequency- Appx. 6 cycles/min
Amplitude-.1336 comparative units

Pre- CV4 OMT
Doubled slow wave frequency \(\approx\) Increased blood flow to brain

Increase in Amplitude directly proportionate to increase in cranial compliance

2\textsuperscript{nd} Harmonic arrival \(\approx\) skull expansion; stems from energy increase of the slow fluctuation

Post CV4 - Moskalenko Interpretation
Moskalenko Method: Intracranial volume-pressure relations by analyzing TCD & REG changes during a cardiac cycle.

- Equalize amplitudes.
- Isolate TCD & REG changes on ascending and descending phases of the cardiac cycle.
- Transform coordinate axis from "amplitude/time" to "TCD/REG".
- Change orientation of abscissa for descendant phase of cardiac cycle and its phase in the united graphic.
- Calculate.
Moskalenko Method in Evaluating CRANIAL COMPLIANCE & CSF (Mobility)
Can measure right & left hemispheres

Results of the calculations including **cranial compliance** on each hemisphere side and **CSF flow** for the cardiac cycle of a 26-year-old healthy man recorded at rest, in a comfortable horizontal position.
Responses to holding breath & the Stookey test in a healthy young adult male. (Correspond to rest conditions in previous Figure.)
CSF mobility in response to voluntary breath holding for 30-seconds (27 y/o)
Reproducibility Related to OMT: Quantifying What We Did

• IsoTOUCH® pressure sensor palpation monitoring system
How does our touch compare?

I just can’t believe I’m touching “the” Dr. Frymann!

Is my touch anywhere near close?
Research Protocol & Materials for CV4
Gathering Data for Moskalenko Method
TCD/ REG Measurement Protocol --

Baseline Functions : OMT : Post-OMT Functions

OMT selected with potential to modulate physiology:
- CV4
- Venous Sinus Drainage
- OM Suture Release
- Occipital Decompression
- Sub-Occipital Release
- Sham

Repeat Functional Tests to Physiologically Modulate Vascular Fluid Flow
CV4 Pressure measured using IsoTOUCH® Pressure Monitoring Sensor System (Thenar Pads bilaterally). Only one pad displayed above.
Not Just For Head Trauma / TBI

Pre- and Post- OMT in:
• Healthy → MOA
• Headache
• Hypertension
• etc

Cranial Compliance & CSF Removal of Metabolites / Waste in:
• Dementia
• Neurodegenerative Disorders
• etc
CSF Mobility & Cranial Compliance Change with Age

Right hemisphere

Age 19

\[ \Delta V = \text{max} \]

\[ \Delta P = 0 \]

\[ \Delta P = \text{max} \]

\[ \Delta V_{\text{real}} = 0.98 \]

\[ T = 0.19 \]

\[ CSF_m = 0.42 \]

\[ CC = 0.88 \]

Age 29

\[ \Delta V = \text{max} \]

\[ \Delta P = 0 \]

\[ \Delta P = \text{max} \]

\[ \Delta V_{\text{real}} = 0.94 \]

\[ T = 0.14 \]

\[ CSF_m = 0.38 \]

\[ CC = 0.76 \]

Age 54

\[ \Delta V = \text{max} \]

\[ \Delta P = 0 \]

\[ \Delta P = \text{max} \]

\[ \Delta V_{\text{real}} = 0.90 \]

\[ T = 0.21 \]

\[ CSF_m = 0.24 \]

\[ CC = 0.72 \]

Left hemisphere

\[ \Delta V = \text{max} \]

\[ \Delta P = 0 \]

\[ \Delta P = \text{max} \]

\[ \Delta V_{\text{real}} = 0.96 \]

\[ T = 0.12 \]

\[ CSF_m = 0.47 \]

\[ CC = 0.94 \]

\[ \Delta V = \text{max} \]

\[ \Delta P = 0 \]

\[ \Delta P = \text{max} \]

\[ \Delta V_{\text{real}} = 0.96 \]

\[ T = 0.20 \]

\[ CSF_m = 0.27 \]

\[ CC = 0.88 \]

\[ \Delta V = \text{max} \]

\[ \Delta P = 0 \]

\[ \Delta P = \text{max} \]

\[ \Delta V_{\text{real}} = 0.92 \]

\[ T = 0.15 \]

\[ CSF_m = 0.20 \]

\[ CC = 0.86 \]
CSF Mobility Changes with Age

MOBILITY OF CSF (normalized units)

AGING GROUPS

before 10 10-15 16-25 26-35 36-45 46-55 56-65 66-75

• Changes with age of CSF mobility, calculated as the average of two indices — “SQ” and “T.”
Dementia Stratification (78-84 y/o):
Cranial Compliance & CSF

Group I: mentally healthy, Gr II: initial dementia, Gr. III: moderate dementia, Gr IV: pronounced dementia. Significance $* p > 0.1$, $** p > 0.05$. 
Collaborative Research Cranial Compliance & CSF Flow

- Transcranial Doppler & Rheoencephalography
- Moskalenko Method
- CC: Altered in Dementia? In Multiple Sclerosis? In Head Trauma? In ADHD?
- See if $\Delta$ Pre-Post OMT
Plan of Action

- Write full protocol & grant application
- Recruit and train clinical research teams in TCD/REG
- Train in standardized OMM protocol
- Conduct & publish study data / results

- Share findings
  - AAO
  - Cranial Academy
  - ECOP
  - JAOA
  - Mainline basic science journal

- Apply for larger externally funded study
Questions?

Don't trust him, David - he's an authority figure.
New Ideas Forum: Thanks to the AAO

Looking forward to further discussion
Please feel free to poke holes in any weak aspects of our new ideas to make them (and us) stronger
CHANGES OF CIRCULATORY–METABOLIC INDICES AND SKULL BIOMECHANICS WITH BRAIN ACTIVITY DURING AGING

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