PTSD, Vagus Nerve, and Social Withdrawal: Heart-rate Variability as an Indicator of Symptom Severity and a Treatment Target for PMHNP’s

Chance Nicholson, MSN, PMHNP-BC
Teena McGuinness, PhD, CRNP, PMHNP-BC, FAAN
Daniel Wyers, MSN, CRNP, PMHNP-BC

Conflict of Interest and Disclosure Statement

The speakers have no conflicts of interest to disclose.

Learning Objectives

1.) Describe the role of the vagus nerve in PTSD symptomology with particular emphasis on social, cognitive, and emotional function.

2.) Identify heart-rate variability (HRV) as a potential clinically-objective tool for assessing symptom severity and/or treatment response in PTSD.

3.) Discuss the use of heart-rate variability devices in a clinic setting.
**PTSD**

- Chronic and debilitating mental disorder which affects approximately 8-10% of the general population and 15% of those returning from combat.

- Characterized by:
  1. Re-experiencing trauma
  2. Alterations in arousal and activity
  3. Emotional numbness and avoidance
  4. Dysregulation of cognitive, emotional and social processing

---

**PTSD and Hyperinflammation**

- Number of studies have found increased pro-inflammatory mediators (cytokines, Th1 & 17, etc.) and reduced anti-inflammatory mediators (IL-4, Treg, etc.) are predictive of symptom severity

- Retrospective analysis of Iraq and Afghanistan vets in the VA system identified a drastic increase in the development of inflammatory disorders (e.g., IBS, lupus, etc.) compared to civilians.

---

**PTSD and Hyperinflammation**

- Prospective study of Marines showed increased pro-inflammatory mediators predicted post-deployment PTSD

- Autonomic dysfunction results from chronic-inflammation likely due to disrupted vagal-sympathetic arousal.
Vagus Nerve

- The vagus nerve “wanderer” or cranial nerve X is a major component of the autonomic nervous system that influences neuronal, endocrine, and immune functions.

- Primary role is physio-inflammatory homeostasis: regulates gastrointestinal, cardiovascular, respiratory, and select cognitive function via its autonomic parasympathetic control.

- Exerts a powerful immune effect via its cholinergic anti-inflammatory pathway.\(^4\)\(^5\)

Vagus Nerve and PTSD

Neurovisceral Integration Model (Thayer & Lane, 2000)

- Vagal connections permit a cardio-cortical information exchange which regulates metabolic changes via inhibitory parasympathetic activity.

- Allows for an adaptive central nervous system which can respond effectively to environmental changes (i.e., stressors).\(^6\)

Vagus Nerve and PTSD

Polyvagal Theory (Porges, 2007)

- Vagal-autonomic subsystems:
  1. Social communication (e.g., facial expression, listening, etc.)
  2. Mobilization (e.g., fight-flight)
  3. Immobilization (e.g., withdrawal, behavioral dysfunction, etc.).\(^7\)
Vagus Nerve and PTSD

1.) Re-experiencing trauma
   - dyregulated fear extinction interferes with memory formation and consolidation
   - hyper-acquisition of fear, disrupting plasticity in the amygdala and preventing extinction learning

2.) Alterations in arousal and activity
   - disrupted control over sympathetic nervous system

3.) Emotional numbness and avoidance
   - sickness syndrome

4.) Dysregulation of cognitive, emotional and social processing
   
   **Cognitive**
   - prefrontal cortex function is reduced in favor of norepinephrine’s stimulation of the amygdala and HPA-axis (stress pathways).
   - decreased vagal tone: impaired executive function, speed of processing, attention, and psychomotor speed

   **Emotion**
   - altered brainstem nuclei activity disinhibits the amygdala and medullary cardioacceleratory circuits which destabilizes affect

   **Social withdrawal**
   - inflammation is inversely associated with the degree of withdrawal
   - inflammation disrupts oxytocin and encourages withdrawal
How Do We Measure Vagal Function?

**Heart-rate variability (HRV):** quantitative assessment of variation in interbeat intervals. Modulated by parasympathetic and sympathetic branches via sinoatrial node.

**Frequency**
- **Low frequency (LF):** stated to reflect baroreflex (sympathetic and parasympathetic activity)
- **High frequency (HF):** represents (parasympathetic vagal-tone).
- **LF/HF ratio:** indirect index of sympatho-vagal balance

**Time Domain**
- Standard deviation of all N-N intervals (SDNN) and Root mean square of successive differences (RMSSD)

How Do We Interpret HRV in PTSD?

- HRV and its HF component is reduced (with increased HR) compared to controls whilst the low-frequency (LF) component is elevated.
- Increased LF/HF ratio and decreased SDNN, RMSDD indicates reduced HRV
- Reduced HRV in PTSD suggest *autonomic inflexibility* due to sympathetic overactivity and/or parasympathetic insufficiency

HRV and PTSD

- Unlike controls, PTSD patients demonstrate no LF or HF reactivity to recalling a traumatic event
- Diminished HRV before trauma increase the likelihood of stress disorder symptoms after trauma.
- Diminished HRV immediately after trauma can predict development of PTSD
**HRV and PTSD**

- HRV at rest determines degree of pre-frontal cortical activity and intrusive thoughts
- Early detection of dysautonomia can predict onset of depression in PTSD and TBI patients

**What Comorbidities in PTSD and Factors Affect HRV?**

- Chronic pain, chronic fatigue syndrome, or fibromyalgia
- Metabolic disorders
- GI disturbances (e.g., IBS)
- Eating disorders
- Breathing problems or asthma
- TBI
- Cardiovascular disorders
- Sleep disorders (i.e., sleep apnea)
- Depression
- Smoking
- ETOH and illicit drugs
- Gender
- Age
- Obesity
- Medications

**Treatment and Therapies That Can Improve HRV**

- **Medications**
  - ex: prazosin, beta-blockers, ketamine, cyclobenzaprine, citalopram, fluoxetine
- **Psychotherapy**
  - ex: Cognitive Processing Therapy, CBT, & EMDR
- **Exercise**
  - improves cardio-cortical inhibitory control of intrusive thoughts; regulates arousal; and increases adaptiveness to metabolic stress
Treatment and Therapies That Can Improve HRV

- **Yoga and Mindfulness**[^10,^40]
  - improves homeostatic capacity and autonomic, metabolic, and physiological resilience

- **HRV-Biofeedback**[^41,^42,^43]
  - significant reduction in pro-inflammatory markers
  - effect on HRV (increasing tonicity)
  - reduces PTSD symptoms and provides general health benefits

---

Treatment and Therapies That Can Improve HRV

- **Vagus Nerve Stimulation (transcutaneous/aurical)**[^44]
  - tVNS downregulates inflammatory mediators via cholinergic anti-inflammatory pathway

- **Other neuromodulatory techniques**[^45,^46]
  - transdermal electrical neurosignaling
  - transcranial direct current stimulation (tDCS)

---

How Can We Measure HRV in Practice?

- **Devices**
  - Actiheart
  - Biofeedback Stone
  - Bioforce HRV
  - BLE HR & HRV Recorder
  - Breathe Sync™
  - CardioMood HRV Expert
  - Cardiofit
  - Elite HRV
  - emWave2/PRO
  - Firstbeat Technologies
  - FitPal
  - Polarband
How Can We Involve Patients?

The ABCD’S

- **Apps and HRV technology:**
  1. Feasibility; 2. Compatibility; 3. Interpretability
- **Benefits:**
  1. Education; 2. Fitness; 3. Well-being
- **Coach:**
  1. Motivation; 2. Exploration; 3. Communication
- **Determine next step in treatment**
  1. Hesitation; 2. Readiness; 3. Exposure

Questions?