Introduction

How does task-induced fatigue affect surgeries?
- Successful surgeries not only depend on the procedure itself but also the surgeon’s ability to detect critical cues (i.e., the ability remain vigilant), which can cause task-induced fatigue.
- Critical cues can include alarms in the operating room or information from nurses regarding the patient.
- The possibility of overwhelming task demands is especially concerning for personnel working in medical environments, as medical errors have been associated with 30% of surgical deaths (Fenwick et al., 2002).

How does this affect laparoscopic surgeries?
- Surgeons performing laparoscopic surgeries may be particularly at risk to high task loads, because they must view target tissue indirectly via a camera.
- This results in a disruption of hand-eye mapping, placing additional strain on their cognitive resources (Tripp & Warm, 2007).

How can we use HF/E to improve this situation?
- Real-time indicators of task-induced fatigue would be useful in determining when a medical professional reaches critical thresholds of attentional depletion and such indicators could be used to enhance patient safety and optimize medical training.
- Measures of cerebral blood flow velocity (cBFV) may satisfy this goal, as cBFV has been correlated with attentional load (Saggar et al., 2004).
- For example, Tripp & Warm (2007) suggested this method be used for identifying air traffic controllers that have reached critical levels of attentional load and task-induced fatigue.

How is the current study valuable?
- The current study is innovative because it utilizes a new method (i.e., Transcranial Doppler Sonography) to identify attention load and task induced in real-time.
- Other popular physiological measures, such as functional magnetic resonance imaging, are not feasible in real-time monitoring in surgery settings as they require personnel to remain still.

Objective: Determine whether cBFV is a valid real-time indicator of attentional load and task-induced fatigue in the laparoscopic surgery setting.

Method

Participants
- 34 novice participants (1st or 2nd year medical students) were recruited from Texas Tech University Health Sciences Center.

Transcranial Doppler Sonography (TCD)
- The Doppler-BoxTM Xtranscranial Doppler ultrasound system (DWL, Germany) was used to isolate the participant’s left and right middle cerebral arteries as this artery is typically monitored in vigilance research (Klein et al., 2015).
- See Figure 1.

Vigilance Task
- The participant was asked to monitor patient vital levels by pressing a foot pedal when they heard a critical (or “dangerous”) sound (200 ms burst of noise).
- Participants refrained from pressing the foot pedal when they heard a neutral (or “safe”) sound (247.5 ms burst of noise).

Procedure

1. TCD Application
   - Experimenter applies the TCD onto the participant.
   - Record 5 min baseline.

2. Practice Sessions
   - 12-min Peg Transfer Task Only
   - 2.5 min Auditory Task Only
   - 5-min Dual Task

3. Experimental Session
   - 5-min Rest Period
   - 40-min Experimental Trial

Results

Validity Assessment of a Real-Time Indicator of Task-Induced Fatigue among Novices in the Minimally-Invasive Surgery Environment

Theresa Nguyen¹, Martina Klein¹, Eric Greenlee¹, Dixon Santana², John Griswold², Krishnanath Gaitonde³, & Neal Ellis²
¹Texas Tech University, ²Texas Tech University Health Sciences Center, ³University of Cincinnati

Discussion

cBFV decreased significantly across periods.
- As novices complete the surgical procedure, their attentional resources become depleted, which is representative of cognitive fatigue.
- This decrease occurs regardless of condition (0° or 90°), indicating that cBFV of the MCAs may not be sensitive to variations in task difficulty associated with variations in perceptual-motor distortions.

The decrease in cBFV is reflective in participants’ performance decrement during the vigilance task.
- The percent correct detection decreases over periods and reaction time increase over periods, suggesting that changes in cBFV of the MCAs over time correspond with performance changes on secondary vigilance task in novices in the laparoscopic training environment.
- Again, this trend occurs regardless of condition.

The peg-transfer task indicated that performance was superior in the 0°, consistent with previous research (Tripp, Weimer, & Cooper, 2010).

Future Direction: Data collection on laparoscopic experts is ongoing. Experts are assumed to have their attentional resources less taxed and will be able to use their cognitive resources more effectively. A valid real-time assessment of attentional needs to be sensitive to identifying these differences.