Cardiovascular Variability and Respiratory Influences under Hyperbaric Conditions

Introduction

- Known affects of atmospheric pressures greater than 1 atm
  - Heart rate variability
    - Health
    - Unhealthy
  - Affect on blood O2 saturation
  - Changes in respiration
- Recreational scuba diving and common medical treatments
  - Roughly 4 atm at 30 m (in sea water)
  - 2.5-3 atm used in medical treatments
  - What does this do to the function of the heart
    - Are there any long term effects
    - Dangers of scuba diving
    - "Normal" reaction to increased atmospheric pressure
- Unknowns
  - Is controlled breathing linked to HRV
  - Additional information for scuba divers
- Outline of paper
  - Background info
    - Brief history of scuba diving
    - Brief history of hyperbaric medical treatments
  - Methods used for studying normal response to pressure
    - Professional divers
    - Controlled breathing
  - Results of study
    - Contradict previous study
    - Increased Vagal tone
  - Discussion
    - Possible problems with study
    - Indicative of normal medical treatment response?
  - Conclusion

Background

- Heart is capable of functioning under significantly increased pressures
  - Depths of 100 m below sea level
  - 3 atm
    - Used in medical treatments, CO poisoning, deep wounds…
- What is challenging about this stress
  - Deep sea divers
    - Oxygen toxicity
      - Slows breathing
    - Increased outside pressure on heart
  - Medical treatments
    - Hyperbaric hyperoxia induces bradycardia
    - Hyperbaric air (O_2 21% at ≥ 2.5 atm)
      - What affects do these have on the heart and respiration

- Method of analysis
    - 4 min ECG recordings
    - HRV- how it is calculated and its purpose
        - HF and LF

Methods (Lund2000)

- Male professional divers
    - Controlled breathing 15 breaths per min
    - Followed time table used in hyperbaric oxygen (HBO) medical treatments
- 4 minute ECGs following reaching a level of pressure
    - After 30 min of rest at 1 atm
    - After reaching 2.5 atm for 30 min
    - After exposure to 2.5 atm for 55 min
    - After ascending to 1.6 atm
    - After decompression
- Study done for both 100% O2 and 21% O2 (normal air)
- Statistical analysis of HRV

Results (Lund2000)

- Heart rate decreased with increased pressure
    - Results similar for both cases
- HRV increased for both cases
    - HRV greater for 100% O2
        - Greater HF (high frequency) component
        - Greater LF (low frequency) component
- Arrhythmias
    - Increased QT and PQ durations
        - Due to vagal response

Discussion:

- What triggers a parasympathetic response to increased pressure?
    - Increased outside pressure on the heart
    - Increased O2 concentration in blood
    - Respiration (maintained constant across study)
- Mechanisms
    - Reduced venous flow
        - Shift of pressure-flow graphs (Aldea2000)
        - Excess O2 due to increased pressure
    - Slower heart rate
        - Reduced venous return
        - Increased vagus response
            - Increased O2 in blood
            - Increased outside pressure on heart
        - Effective reduction in ventricular capacity
    - Controlled breathing
        - Probably reduced volume

- Weakness
    - Controlled breathing
        - Although compensated in analysis, affects other mechanisms
        - Not typical of patients receiving hyperbaric treatments
    - Professional Divers
        - Trained response to exposure to pressure
        - Developed compensatory mechanisms
        - Much lower pressures than what professional divers experience
        - Potential panic likely to be seen in patients not present
- Questions
    - How would this change with less experienced divers
    - What would change without controlled breathing
        - Less obvious changes in HRV
            - Lungs would help compensate (i.e. slower respiration rate)