EEG Signatures Associated with Pre-Emergent Induction of Anesthesia Dreams Across Three Propofol Protocols

J. Lee[1], T. Ishii[3], P. Sikka[3], M.Kawai[4], B. Heifets[2], H.Chow[1]

[1]Stanford Health Care, Department of Anesthesiology, [2]Stanford Medical School, Department of Anesthesiology, [3]Department of Psychology, Stanford University, [4]Department of Psychiatry, Stanford University

Background

- Depth of anesthesia can be monitored with electroencephalography (EEG). While anesthesiologists often use distinct EEG patterns to monitor a patient's depth of anesthesia, the question remains whether the phenomenon of vivid dreams during surgical anesthesia can too be characterized by distinct EEG patterns.

Objectives

- To identify specific EEG signatures using a 4-lead frontal SedLine monitor in patients experiencing anesthetic dreaming under 3 different pre-emergence protocols

Methods

- Sample: 869 patients undergoing anesthesia induction
- Setting: Stanford Medical Center
- Time: July 2020 – July 2024
- We followed an institution-based anesthetic (Total IntraVenous Anesthesia) protocol for two of three propofol-based emergence protocols: intra-operative infusion of propofol-only or propofol-remifentanil. The third propofol-based protocol included propofol-sevoflurane.
- Each patient's EEG was recorded using a 4-lead frontal SedLine monitor.
- We attempted to achieve and maintain pre-emergent anesthetic state using TIVA-based anesthetic titration for at least 5 minutes with EEG guidance.
- Method: Identified specific EEG signatures indicative of transition from unconsciousness to wakefulness

Results

- Of the 869 patients undergoing anesthesia induction, 554 reported dreaming with one of the following pre-emergence protocols:
  ○ Propofol-only
  ○ Propofol-remifentanil (pre-dominant)
  ○ Propofol-sevoflurane (sevo)
- Of the 154 propofol-only patients:
  ○ 97 reported dreaming
  ○ 78 were able to recall their dreams
- Of the 694 propofol-remifentanil patients:
  ○ 444 reported dreaming
  ○ 397 were able to recall their dreams
- Of the 21 propofol-sevoflurane patients:
  ○ 13 reported dreaming
  ○ 7 were able to recall their dreams

869 Patients Under Anesthesia

Non-Dreamers 315 | Propofol 97 | Propofol-Remi 444 | Propofol-Sevo 13 | Dreamers 554

Prop-Remi: Pre-emergent state (clinically associated with patient dreaming), PSI > 50, small, narrow, fast, stable EEG (5 minutes). Alpha (red) band fading with delta (red) band remaining on spectrogram. Beta (blue) band emergence.
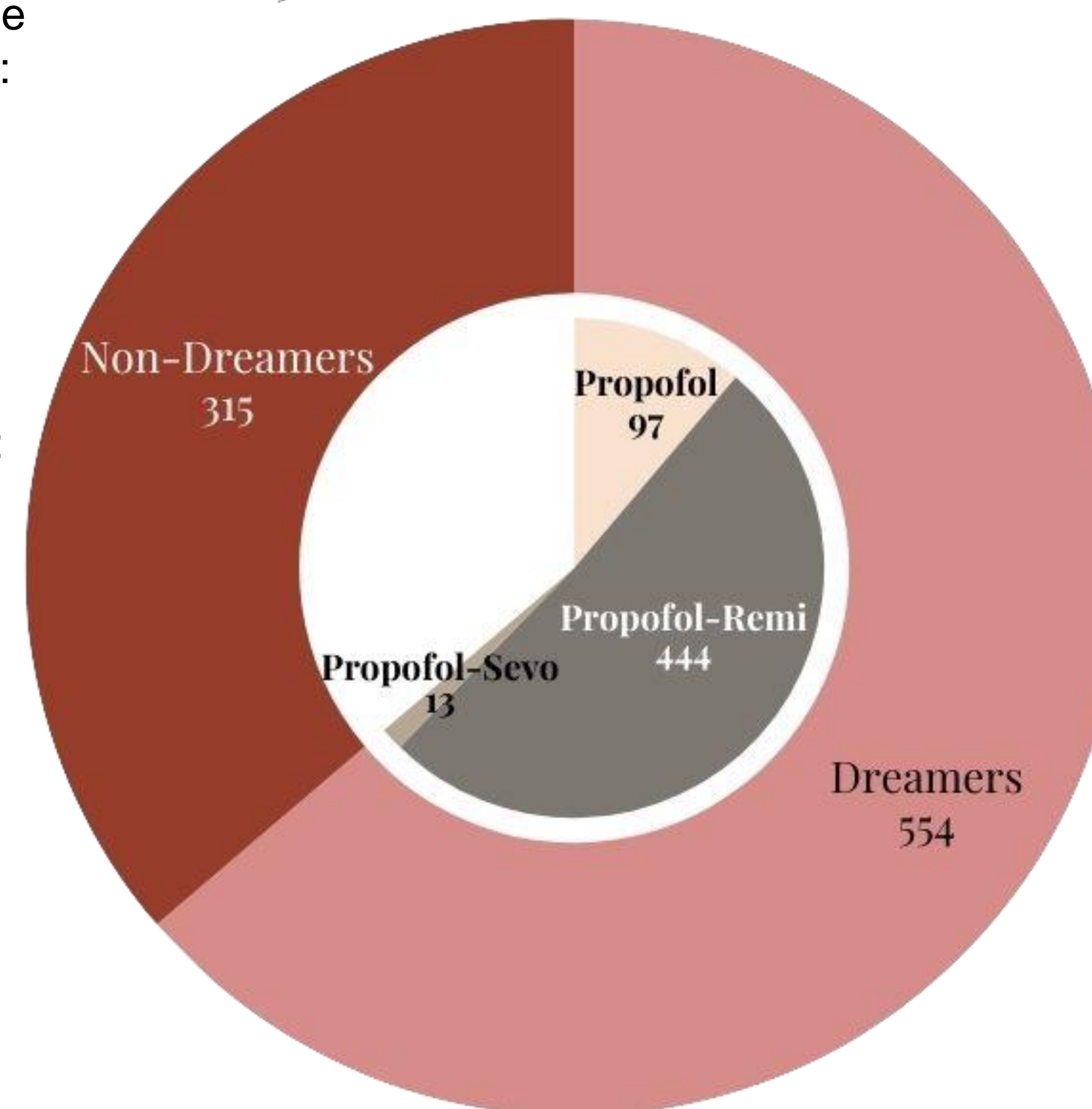
- Across all three anesthesia protocols, we commonly observed consistent EEG patterns at the pre-emergence state characterized by:
  ○ **Delta Band Fade**
    ▪ Gradual reduction of low-frequency delta waves *preceding* alpha band fade
  ○ **Alpha Band Fade**
    ▪ Gradual reduction in alpha band activity *following* delta band fade
  ○ **Beta Band Emergence**
    ▪ *Subsequent* increase in beta band activity and distinct beta band on spectrogram
- These findings were consistently noted in pre-emergence anesthesia spectrograms of patients induced with all three protocols.
- No significant marker existed that differentiated one induction method from the others.

Conclusions

- Our findings suggest that there exist target EEG signatures associated with the pre-emergent induction of anesthesia dreams – specifically the decrease in delta band power, and the alpha band fade followed by beta band emergence – common across different anesthetic protocols involving Propofol.
- Consistency in EEG patterns could serve as a reliable biomarker for monitoring anesthesia-induced dream states.

Implications

- This study suggests that there may be a common neural mechanism underlying the induction of anesthesia dreams across multiple anesthetic combination and irrespective of surgical procedure performed.
- Further clinical research and experience should be encouraged to explore the implications of these findings to enhance the study of anesthesia dreams and patient care.
- An identifiable and reproducible anesthesia dream biomarker may be used to identify clinical therapeutic and research applications involving human consciousness and psychiatric disorders such as post-traumatic stress disorder (PTSD).
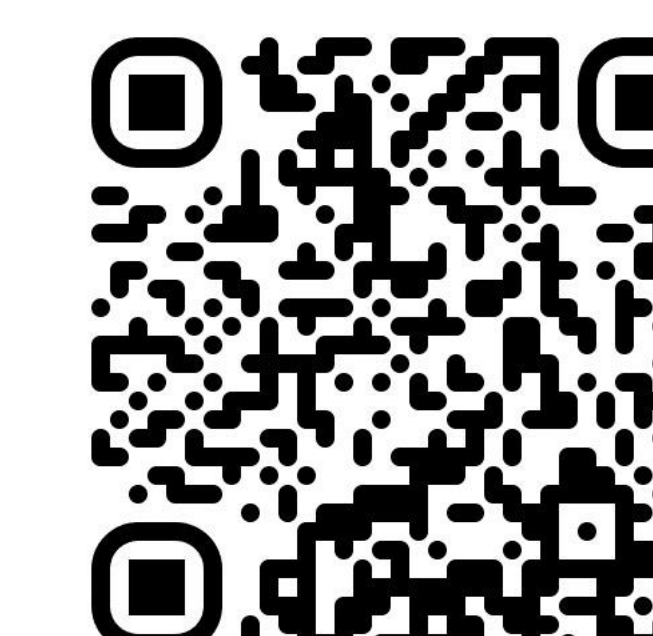
Patient stories
Two Mothers from Palo Alto
For dream illustrations:
✕ @drpuppychow
@TheBorisLab