Anthony Kaveh and Jason Bouhenguel | R in Anesthesiology at BWH, PGY 2

**Title:** Professor of Anesthesiology

**PI Information:** James Philip, Professor of Anesthesiology -- jphilip@partners.org

**Faculty Sponsor:** James Philip, Professor of Anesthesiology -- jphilip@partners.org

**Additional Investigators:** None

**RESEARCH NARRATIVE**

**Problem to be addressed:** Anesthesia medications are given based on general trends across populations. While anesthetics are individualized to patients at a high-level based on medical history and the specific surgery, providers currently lack reliable tools for predicting and optimizing intraoperative medication dosing. With surgical advances enabling care of increasingly higher risk patients, new anesthetic techniques and monitoring technologies present an unprecedented challenge for the provider to efficiently and effectively interpret and integrate all available data in real-time.

Despite the availability of high-resolution intraoperative sensors and electronic medical records (EMR), a data platform at Brigham and Women's Hospital (BWH) has not yet been made available to utilize this valuable data collection. Given BWH's high operative volume and diverse patient characteristics, this data can be used to construct individualized, mathematical predictive models to better utilize intraoperative monitors and deliver advanced, expert anesthetic care to optimize patient safety and operating room efficiencies.


**Study Hypothesis:** We hypothesize that an infrastructure providing high resolution physiologic data obtained from standard ASA monitoring systems and anesthesia machines can be used to build robust patient-
specific physiologic models, especially when linked with the EMR to provide medical history, medications, and demographics. Models predicting and recommending optimal intraoperative management may improve anesthetic efficacy (eg better pain control, reduced awareness), patient safety, and operative-care efficiency (eg reducing emergence and recovery times). This may be achieved with optimizing intraoperative medication dosing (such as analgesics and opioids, anesthetics, muscle relaxants, vasoactive medications, fluids, blood products) and other non-pharmacologic interventions (such as ventilator settings, patient positioning, thermoregulation). Our hypothesis is that these models can provide an innovative and scalable intraoperative, real-time decision support system. Key applications include decreasing medication dosing errors ("over-" and "undershooting"), improving intraoperative hemodynamic stability and blood product use, decreasing opioid dosing, and reducing emergence times to increase operating room efficiency.

**Population:** We plan to collect intraoperative and procedural data from all patients receiving anesthesia in BWH OR and procedural suite settings that are equipped with anesthesia machines.

**Description of intervention or study design:** Our ultimate goal is to innovate a real-time, intraoperative decision support system for anesthesiologists to improve patient safety, anesthetic efficacy, and operating room efficiencies. Plan and objective measures are outlined below in three phases. The current funding proposal is for Phase I development. Phase I: Data acquisition. Currently, intraoperative patient data is limited to only several low-resolution (1 minute) physiologic parameters and no automated medication dosing information. Raw patient data is already being sampled at >100Hz and available throughout the BWH hospital network with the current infrastructure; however, most physiologic parameters are either never stored or significantly downsampled when documented in the EMR, greatly sacrificing the majority of the rich data originally collected. In partnership with the makers of many of our anesthesia machines (General Electric, GE), our proposal will add an additional server to capture, store, and make available this high resolution patient data collected during surgery from BWH anesthesia machines. Therefore, our Phase I goal is to store data prior to downsampling, including both physiologic measurements from anesthesia monitors (heart rate, blood pressure, etc) as well as precise records of medication administration, including type, dose, and timing (mm:ss) through implementation of an infusion line monitoring system. This data will be temporally correlated and formatted to enable analytics of patients’ surgery courses. Exporting this high resolution data will enable data analysis for Phase II. Phase II: data optimization and feature extraction for predictive modeling. In addition to enabling review of the surgery course for quality and education, the data made available through Phase I will be used to model patient physiology during surgery, including surgical stimuli and medication dosing and timing. Mathematical models will be constructed from features extracted and optimized from the high resolution data to characterize the physiologic impulse response by the patient. Notable features available only from high resolution waveform data include heart rate variability, pulse pressure variation, and spectral analysis of plethysmogram and capnogram, none currently available from the downsampled data documented in the EMR. Data optimization includes artifact rejection at the waveform level, including arterial line whipping and electrocautery interference. Modeling will include statistically correlating these physiologic responses to inputs. Data will be stratified by patient age, gender, ASA-status, case type, and relevant comorbid conditions (hypertension, coronary artery disease, diabetes mellitus, etc). Phase III: clinical evaluation of predictive modeling. The models produced in Phase II will be tested for clinical effectiveness by studying patient outcomes in two groups: one group of patients anesthetized with providers using decision support from Phase II models, and the other patient group cared for with the current standard of care. These two groups will be normalized by ASA-status and surgery type for effective comparison. We define decision support as using patient models to notify providers of optimal times for medication dosing/redosing to maximize desired outcomes. Key outcomes include quantity of medication used (eg opioid use), emergence time, recovery time, adverse effects, patient safety, post-operative patient comfort, and time to discharge.

**Description of comparison group (if relevant):** In the final phase of this project (Phase III), the decision support models constructed using Phase I data will be used to compare patients receiving current anesthesia standard of care to patients receiving anesthesia care from providers using decision support to optimize anesthesia delivery (as outlined in question
12). The comparison groups will be matched by patient demographics, comorbidities, and surgical case type. Notably, this proposal is only for Phase I of this project.

**Outcome variable to be used to determine efficacy of the intervention (if relevant):** Outcomes include quantity of medication used (eg opioid use), intraoperative stability (hemodynamic, depth of anesthesia), incidence of adverse events, incidence of reported patient awareness, recovery time/length of stay, post-operative patient comfort (incidence of nausea/vomiting, pain scoring), and operating room efficiency (eg case time, emergence time).

**Power analysis to determine feasibility (when relevant):** Power analysis for Phase III of this proposal will be determined upon completion of Phase II, when the model parameters have been established to inform the number of patient and surgical demographics for which our models will provide decision support.

**Timeline:**

- **Months 1-7:** Phase I: development of data collection platform
- **Months 8-16:** Phase 2: construction of predictive modeling
- **Months 16-26:** Phase 3: intervention of decision support system

**IRB Status of Project:** The protocol will not be submitted for IRB.

**BUDGET**

**Line item budget and budget narrative:** Our Phase I development of the data collection platform will begin with a pilot of 1 anesthesia machine and 1 server platform to collect and export data in a test environment. Once data integrity is validated, further licenses will be obtained and server bandwidth upgraded to accommodate a larger data collection environment.

- Single OR anesthesia machine license: $500
- Data collection/export server: $2000
- Data storage: $500
- **Total Budget:** $3000

**Disclosure of other funding sources:** This grant would be sole source of funding.

**LETTERS OF SUPPORTS**

**PD Name:** Morana Lasic  
**Letter of Support Received?** yes

**Mentor Name:** James Philip  
**Letter of Support Received?** yes

**OTHER**

**COE Involvement:** No dinner sessions or courses yet attended.

**Previous COE Funding:** N/A