STA Interface
NEWSLETTER

SOCIETY FOR TECHNOLOGY IN ANESTHESIA • MARCH 2022

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President's Message

LARA BREWER, PHD
University of Utah

On behalf of the Society for Technology in Anesthesia (STA), I extend gratitude to our Immediate Past President, Dr. Maxime Cannesson, and the Board of Directors for their leadership during the previous year. It was a challenging year with many unknowns and unexpected turns, and they did an excellent job navigating uncharted territory for our Society.

Thank you also to those who have stepped up to contribute to the Society's efforts both individually and through committee work, and thank you to our Executive Director, Marie Odden. Our second (and we all hope, last) Virtual Annual Meeting, titled "Innovation for a Sustainable Future" in January 2022 was a great success thanks to the creative efforts of the Annual Meeting Program Co-Chairs, Drs. Olivia Nelson and John Pearson. The on-demand video presentations of the meeting content this year again gives our physician members access to AMA PRA Category 1 CreditsTM. The real-time, online discussion during the Annual Meeting around the timely topic of sustainability was stimulating and engaging. I look forward to the cutting-edge innovations our membership will contribute in the future towards improving sustainability in medicine.

I would also like to extend deep appreciation to our corporate members. Their unwavering support during this pandemic has been extremely valuable for the integrity of our Society, and we look forward to interacting and collaborating with them in person, as well as remotely, throughout the year.

Thank you to the approximately 75 STA members who participated in the February 2022 Zoom meeting with the FDA to comment on the draft guidance on Technical Considerations for Medical Devices with Physiologic Closed-Loop Control Technology. This has been an eagerly awaited guidance from the FDA, and we appreciate the opportunity initiated by Dr. Julian Goldman, Chair of the STA Standards Committee, to submit comments on it. This is an example of how our membership continues to inform advancement in technology.

Our Society's unique, collective experience in the intersection among clinicians, business partners and engineers has a legacy of making

President's Message *continues on page 3*

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President's Message *continues from page 1*

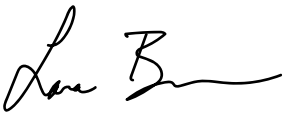
a positive difference in advancing technology for patient care. Congratulations to Dr. Samsun Lampotang, who received the 2022 J.S. Gravenstein Award for lifetime achievement in the area of technology in anesthesia. It was an honor to celebrate Dr. Lampotang's contribution to advancement in technology and to learn more about his journey in improving technology in clinical practice.

The strong connection and collaboration among our highly engaged and multidisciplinary membership is one of the greatest strengths of our Society. One of my priorities as STA President is to formalize a STA mentorship program. The goal of this new program is to forge meaningful connections among STA members across institutions that will enhance the careers of both mentees and mentors. Watch for more information on this new program coming in the near future.

Upcoming events to watch for include the STA Panel, Artificial Intelligence and Autonomous Systems in the Perioperative Setting, on Saturday, October 22nd from 2:30-3:30pm, as well as the STA Annual Ty Smith Dinner on Sunday, October 23rd during the American Society of Anesthesiologists (ASA) 2022 Annual Meeting in New Orleans, LA. We are planning for an in-person 2023 STA Annual Meeting at the Four Seasons Hotel in Las Vegas, NV from January 11-14, 2023! This is one meeting you will not want to miss!

In summary, I look forward to the continued innovations, improved sustainability and contributions to technology advancement that our STA membership will bring forward this year. I am humbled to lead as President and honored to contribute to STA's continued success and growth this year. I am especially looking forward to a time when we can gather again in one place to share ideas and a passion for technology. Thank you in advance for the impact, relationships and collaborative efforts you bring to our discipline!

Sincerely,



Lara Brewer, PhD
STA President

Message from the Editor

JONATHAN M. TAN, MD, MPH, MBI
STA Communications Committee Chair
Children's Hospital Los Angeles
Keck School of Medicine at the University of Southern California

It is with great expectation that this edition of the STA Interface finds all of you doing well and I hope in a better place than last year. As we all have experienced with COVID-19, the past two years have been extraordinarily challenging, rapidly changing, and simply hard from a personal and professional perspective. Despite all of this, we have also seen first-hand the enormous collaboration, strength, and resilience of individuals to make sure that our patients and those around us were doing well.

I'm particularly proud of the STA and the leadership of the STA Board of Directors. The decision to have the STA 2022 Annual Meeting be virtual for another year turned out to be particularly wise. The increase in cases of COVID-19 during this winter and into January 2022 was particularly high due to the new variant. The planning could not have been better timed. The STA Board has always and will always consider the safety and wellbeing of its members. It was amazing to see such thoughtful, caring, and experienced leaders put the STA members first.

This year's STA Annual Meeting was very much a large success. The speakers, panels, and topics were fantastic. Annual Meeting Co-Chairs, Drs. Olivia Nelson and John Pearson, organized, led, and delivered a true multi-disciplinary meeting that celebrated the importance of technology in all aspects of anesthesiology, perioperative medicine, and our environment. Perhaps the largest measure of success was the incredible engagement of all the attendees. Of all the virtual conferences over the past two years, the STA continues to have such incredible action in the chat box, and a seemingly infinite number of important questions that follow each speaker.

This edition of the STA Interface highlights this past year and in particular the successes of the STA 2022 Annual Meeting. We hope that you enjoy it and thank you to all the contributors to this year's newsletter!

Jonathan M. Tan, MD, MPH, MBI
STA Communications Committee Chair

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Report from the Executive Director

MARIE ODDEN
STA Executive Director

Navigating the STA Annual Meeting During the COVID-19 Pandemic: Both Limited and Limitless Possibilities

We've learned a lot in the second year of the COVID-19 pandemic with two STA Virtual Annual Meetings under our belt. It seems we're stuck between a rock (inherent desire as human beings to want to interact in person and feel some sense of normalcy) and a hard place (the responsibility to patients, friends, and family to do everything in one's power to keep everyone safe). Our team has spent a considerable amount of time planning and discussing how to best navigate the uncertainty of the pandemic. Below is a little insight into the thought process and consideration of the Annual Meeting format, and the limit*ed* and limit*less* possibilities it creates. We hope that this provides some insight into the planning process and our desire to best care for the members of the STA.

Limited

Financial Implications

Of course, as with any responsible association, the STA Board has a fiduciary responsibility to consider the fiscal impact that an in-person, hybrid, and virtual Annual Meeting would have on the Society. As you can imagine, pre-pandemic it was much easier to create scenarios comparing each meeting format. However, when the Board met back in September to decide if STA would be able to meet in person in Las Vegas in January 2022, it was difficult to know what the next 4 weeks would hold, let alone the next 4 months.

I'd like to say it's from years of meeting planning experience that my gut was to pivot virtual in 2022, and that I predicted the Omicron surge would peak the first two weeks of January immediately following the holidays and preceding the Annual Meeting, alas this is not my given superpower!

Moving the meeting from in-person to virtual was not a decision the Board took lightly. After hearing of the potential financial impact an in-person meeting would have if a last-minute cancellation was necessary, each Board member voted independently on their preferred meeting format given the information they had at the time. It's important to note the STA Board is a diverse group of individuals, elected from among their peers, holding different titles varying backgrounds and are located all over the world. The vote was nearly unanimous to go virtual. STA members' safety, along with the safety of their families and the patients they serve was paramount in this decision.

The STA is incredibly thankful for the ongoing support of our Corporate Members. Their ability to pivot with the STA during such uncertain times and work collaboratively to provide feedback on our Corporate Membership packages continues to mutually benefit and foster the relationship between each member and the STA.

Networking and Community

Even given the financial implications, a decision to go virtual for a *second* year in a row wasn't an easy one. I've worked with a many professional societies, specifically medical groups (even *more* specifically, Anesthesiologists) and I've yet to come across one more social or embracing of new members and attendees than the STA. Though you can see the faces and names of those on Zoom, there's no comparison to the networking opportunities and feeling of community than in-person at the STA Annual Meeting. Therefore,

Report for the Executive Director *continues on page 7*

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Report for the Executive Director *continues from page 5*

the strong desire to meet in person is just as important to consider as the potential financial impact when considering the meeting format.

Limitless

In a world that seems very limited right now there are many limitless opportunities with virtual meetings.

Accessibility: At the 2022 Virtual Annual Meeting, STA welcomed almost 200 attendees from nine different countries. Using a virtual format gave individuals that may not have had the opportunity to attend in the past, be it from closed borders or financial restrictions, an avenue to connect with the STA community.

Cost to Attend: Due to the expense of an in-person meeting, it's easy to see why it costs attendees more to attend in-person vs. virtually. The overall costs to organize a meeting – meals, room rental, CME, supplies, printed materials, onsite staffing, etc. – mean increased registration fees to attend. On the contrary, virtual meetings offer a low-cost registration fee, no travel expenses, and the ability to commit last minute, which attracts many attendees with busy lives who are often already over committed. The same is true for Corporate Members as well, with low cost to attend, they can invite more company representatives into the STA community.

Time Away from Family: If anything during the pandemic, it's become apparent to many that personal *time* is irreplaceable – you can't get more of it. Therefore, a virtual format offers less time away from family and friends, and from personal and professional commitments.

Recorded Content: A virtual format offers the opportunity to record the presentations of our exciting and didactic Annual Meeting speakers and offers them as a member benefit to those unable to attend. As a reminder, you can earn up to 8.5 *AMA PRA Category 1 Credits*™ by watching the enduring CME material from the 2022 Virtual Annual Meeting. Visit the STA website and login to claim your credits: www.stahq.org/account/2022-enduring-cme-material

In closing, there are pros and cons to each meeting format – in-person, hybrid, and virtual. At the forefront is safety, with financial impact as a close second. I'm personally optimistic with the recent decrease in COVD cases, and the lifting of mask mandates, that the 2023 Annual Meeting will be in-person at the Four Seasons Hotel in Las Vegas, NV, January 11-14, 2023.

Save the date, stay safe, and as always feel free to reach out with any questions or concerns at 414-389-8600 or marie@stahq.org.

Marie Odden

Marie Odden
STA Executive Director

Registration and Abstract Submission Opens June 2022

2022 Virtual Annual Meeting Recap

This year's STA Annual Meeting followed in the virtual footsteps of 2021 and, despite the distance and challenges, we had an engaging and well-attended meeting with enthusiastic participation. Attendees hailed from a diverse background with participants from 30 states, nine countries, and four continents. Taking place over two days from January 14th through 15th, with a pre-conference industry course geared toward STA Corporate Members, our theme this year was *Innovation for a Sustainable Future*.

Our presentations and panels focused on how we can meet the challenges of reducing waste, controlling emissions, and using new technologies to advance the use of alternatives to inhalational anesthetics. We were pleased and grateful to have Dr. Jodi Sherman of Yale University give our keynote address and demonstrate for all who attended the urgency to act on climate change as well as the agency that we as Anesthesiologists, Engineers, and Scientists must make a difference in this tremendous challenge.

As part of our theme of breaking down silos to produce sustainable change, we also heard from Gary Cohen from Healthcare Without Harm who encouraged all to approach climate and sustainability like a moonshot moment for the healthcare sector. Terri Scannell of Vizient gave attendees insight into how the broader corporate world is approaching environmental and social governance (ESG) issues and how this will shape the future of healthcare.

Within our specialty, Dr. Jonathan Tan of Children's Hospital of Los Angeles used big data to show how we can generate actionable insights into our care delivery through spatial health data. Furthering these themes of big data, a variety of presenters continued our STA's strong commitment to the utilization and optimization of artificial intelligence in medicine. Drs. Priya Ramaswamy and Matthew Zapf broke down the challenges around the use of Machine Learning (ML) in healthcare and how we in the OR can use ML to guide intraoperative transfusion. Clinical Decision Support (CDS) also continued to grow in use for our specialty, with Dr. Seema Gandhi teaching attendees about easy to implement CDS tools that can save on costs and reduce environmental footprints.

Drs. Calvin Gruss of Vanderbilt University and Patrick Kolbay of the University of Utah served as co-chairs of the abstract submission process, and members were pleased to see more than 40 abstracts, covering timely topics from analysis of air quality in pediatric patient populations to use of telemedicine to improve follow up. The awards for the best abstracts are highlighted below.

JOHN PEARSON, MD
STA 2022 Annual Meeting Program Co-Chair
University of Utah

OLIVIA NELSON, MD
STA 2022 Annual Meeting Program Co-Chair
University of Utah

The above presentations are just the tip of the iceberg of all the wonderful content produced for the meeting this year and available on the STA website as enduring CME material from the 2022 meeting. On that note, we are pleased to give STA members the opportunity to earn up to 8.5 CME credits FREE on the STA website: www.stahq.org/account/2022-enduring-cme-material.

We look forward to seeing everyone in person next year at the Four Seasons in Las Vegas, Nevada from January 11-14, 2023, which will be led by Drs. Gruss and Kolbay. Thank you all again for participating and we wish you a healthy and safe 2022!

John Pearson, MD & Olivia Nelson, MD
STA 2022 Annual Meeting Program Co-Chairs

STA 2022 Annual Meeting Abstract Winners

Abstracts Listed on pages 11-19

Click here to see *Best in Show* online

Best in Show

A Random Forest Classifier for Predicting Cerebral Vasospasm Following Subarachnoid Hemorrhage

Presenting Author: David Zarrin, MSE, David Geffen School of Medicine at UCLA

Click here to see *Best Clinical App* online

Best Clinical Application

A Novel Dosing Algorithm for High-Dose Propofol Administration for the Treatment of Depression

Presenting Author: Carter Lybbert, BSc, University of Utah

Click here to see *Excellence in Tech* online

Excellence in Technology

Processed Electroencephalogram Normative Values in Neonates

Presenting Author: Georgia Georgostathi, BS/BA Candidate, University of Pennsylvania

Click here to see *Honorable Mention* online

Honorable Mention

The Development of Non-Contact "Touchless" Monitoring of Respiratory Rate

Presenting Author: Paul Addison, PhD, Medtronic

2022 Engineering Challenge

JEFF E. MANDEL, MD, MS
Mandel Anesthesia Innovations, LLC

The Engineering Challenge is a regular feature of the STA Annual Meeting and was held as part of the STA 2022 Virtual Annual Meeting. As always, the intent of the Challenge is to educate the membership on an area of technology. The subject of the challenge was active management of respiratory humidity.

One of the problems arising during the COVID pandemic was the need to deal with humidity from ventilated patients. Emptying water traps exposes health care workers to contaminated waste, clogged heat and moisture exchangers can reduce ventilation. The goal of the 2022 Engineering Challenge was to demonstrate an active system for managing expired humidity. There were several technologies suggested in the announcement – Peltier junctions, pressure swing absorption, and variable deliquescence salt brines. While there was some initial interest, no group committed to present.

In addition to describing potential approaches to solving the problem, a discussion of the future of the Engineering Challenge was undertaken. There was broad agreement that the Challenge should be announced earlier in the year; Dr. Mandel committed to try to make the announcement in April. Any members with ideas should contact him at jemandel@verizon.net.

2022 J.S. Gravenstein Award: Innovating Patient Safety in Anesthesiology with Education, Simulation, and Technology

JONATHAN M. TAN, MD, MPH, MBI
STA Communications Committee Chair
Children's Hospital Los Angeles
Keck School of Medicine at the University of Southern California

The Society for Technology in Anesthesia (STA) had the opportunity to celebrate Dr. Samsun Lampotang as the 2022 recipient of the J.S. Gravenstein Award. The J.S. Gravenstein Award is named after J.S. "Nik" Gravenstein, a founding member and former President of the STA who committed his career to advancing anesthesia technology, patient simulation, and patient safety. The award is presented to an individual each year for a lifetime of achievement in advancing anesthesiology through technology. This year's awardee, Samsun Lampotang, PhD, FSSH, FAIMBE, had his career's work celebrated by the Society during the STA 2022 Virtual Annual Meeting.

Dr. Samsun Lampotang: Recipient of the STA 2022 J.S. Gravenstein Award

Dr. Lampotang, fittingly, holds the Joachim S. Gravenstein Professorship of Anesthesiology at the University of Florida College of Medicine in Gainesville, and is the Director of the Center for Simulation, Safety and Advance Learning Technology at the University of Florida. He received his PhD in mechanical engineering and has applied his education, talent, and resources toward a research career developing simulation in healthcare, healthcare equipment, and the promotion of patient safety through learning and improved design.

Dr. Lampotang has had an extensive track record of publications that has focused on advancing patient safety through training clinicians to use and make existing processes, equipment, and drugs better, and by improving existing processes, devices, and drugs by analyzing and redesigning them or modifying how they are used. He has taken his research to the bedside many times with successful inventions, technology transfer, and commercialization. Examples of his work include the Human Patient Simulator, Hamilton Max transport ventilator, Accuryn urine output monitor, and others. It is truly amazing to see his expertise applied to research and clinical care across a large variety of health care domains including anesthesiology, neurosurgery, surgery, and urology.

Upon a reflection of his achievements, Dr. Lampotang highlighted his experience having been both a patient and a professional working in health care. It was that personal and professional experience that motivated Dr. Lampotang to commit his career to the care of others and advance the specialty of anesthesiology and simulation. Congratulations to Dr. Lampotang for a lifetime of achievement advancing technology in anesthesia! Your work has improved the safety of patients, the systems of care, and education!

Jonathan M. Tan, MD, MPH, MBI
STA Communications Committee Chair

2022 STA Annual Meeting Abstract Winners

Best in Show

Abstract Title: A RANDOM FOREST CLASSIFIER FOR PREDICTING CEREBRAL VASOSPASM FOLLOWING SUBARACHNOID HEMORRHAGE

Presenting Author: David Zarrin, MSE[1]
Co-authors: Bayard Wilson, MD[2], Bilwaj Gaonkar, PhD[2], Luke Macyszyn, MD[2], Eilon Gabel, MD, MHA[3]
Affiliations: David Geffen School of Medicine at UCLA[1]. Department of Neurological Surgery at UCLA[2]. Department of Anesthesia and Perioperative Medicine at UCLA[3].

Background: Cerebral vasospasm (CV) is a life-threatening phenomenon in patients with subarachnoid hemorrhage (SAH), and is of critical importance since it contributes to delayed cerebral ischemia (DCI) and concomitant morbidity and mortality in this population[1]. It is standard clinical practice to admit patients post-SAH to an intensive care unit (ICU) for 14-21 days following SAH for close monitoring and potential intervention for clinically significant CV. Since current monitoring capabilities cannot determine which patients with SAH ultimately develop CV, considerable hospital resources are consumed supporting and observing many patients with SAH who never develop CV[2].In this context, our group was motivated to explore the feasibility of using machine learning to predict CV in patients following SAH using routinely measured clinical values, with the end goal of guiding clinicians to monitor patients with a level of vigilance commensurate to their actual risk for complication. Herein, we train and validate a random forest classifier for the prediction of CV warranting angiographic intervention using several clinical measures from the electronic medical record (EMR).

Methods: Using the Perioperative Data Warehouse[3], we extracted EMR data from ICU patients who were admitted for SAH at our institution between 2013 and 2021. Time-series of blood pressure (BP), laboratory sera (sodium, albumin, hemoglobin, glucose, creatinine, potassium, and chloride), and intracranial pressure (ICP) were extracted for the entire hospital admission for qualifying patients. CV was defined as angiographic vasospasm warranting intra-arterial verapamil infusion. All datapoints proceeding verapamil administration, unavailable datapoints, and datapoints within time-series with fewer than 100 datapoints at the time-of-prediction were excluded. Each time-series was condensed to a 21-dimensional feature vector by extracting measurements at various percentiles. A random forest classifier was subsequently trained to predict CV based on the described distributions and its predictive power was validated using a five-fold cross validation within the study cohort at 240, 720, 1440, 2160, 2880, and 3600, 4320 minutes prior to verapamil administration. Receiver operator characteristic (ROC) curves and the associated areas under each curve (AUC) were computed to assess predictive power.

Results: A total of 1,534 SAH patients (average age 51.3 years, 45% female) were identified; 1,027 contained complete datasets and were included. Sample sizes at times-of-prediction ranged from 82 to 72 patients based on the count of patients with at least 100 datapoints available. Sample sizes and AUCs for each predictive model at each time interval prior to verapamil injection are shown in Table 1.

Time before Verapamil Injection	Mean AUC			Sample size: verapmil / no verapamil
	BP	ICP	Lab Sera	
240 mins	0.67	0.81	0.71	82/1027
720 mins	0.67	0.83	0.72	81/1027
1440 mins	0.6	0.82	0.71	80/1027
2160 mins	0.63	0.83	0.69	79/1027
2880 mins	0.63	0.8	0.72	77/1027
3600 mins	0.6	0.8	0.72	75/1027
4320 mins	0.62	0.79	0.74	72/1027

Table 1. AUCs and sample sizes for each predictive model.

Conclusion: Our findings indicate that a random forest classifier trained on ICP following SAH is a strong predictor of cerebral vasospasm necessitating verapamil injection up to three days prior to injection (average AUC=0.81). Furthermore, the same classifier trained on BP and laboratory sera achieved less predictive power than when trained on ICP. This report details, to our knowledge, the first machine learning-based approach to strongly predict severe cerebral vasospasm requiring verapamil administration based on routine clinical measurements in the literature.

References

1. Dhar R, Scalfani MT, Blackburn S, et al. Relationship between angiographic vasospasm and regional hypoperfusion in aneurysmal subarachnoid hemorrhage. Stroke. 2012;43(7):1788-1794.
2. Roos YBWEM, Dijkgraaf MGW, Albrecht KW, et al. Direct costs of modern treatment of aneurysmal subarachnoid hemorrhage in the first year after diagnosis. Stroke. 2002;33(6):1595-1599.
3. Hofer IS, Gabel E, Pfeffer M, et al. A systematic approach to creation of a perioperative data warehouse. Anesth Analg. 2016;122(6):1880-1884.

2022 STA Annual Meeting Abstract Winners

Best in Clinical Application

A Novel Dosing Algorithm for High-Dose Propofol Administration for the Treatment of Depression

Presenting Author: Carter Lybbert, B.Sc., University of Utah
Co-Authors: Brian J. Mickey, MD, Ph.D, Kai Kuck, Ph.D., Scott C. Tadler, MD, Jason Huang, M.S., University of Utah

Introduction: Recent evidence suggests that high doses of anesthetics produce significant and durable antidepressant effects in those with drug-resistant depression, comparable to the positive effects of electroconvulsive therapy (ECT) [1][2]. Maintaining a 70-90% EEG burst suppression ratio (BSR) for ~15 minutes seems to yield the strongest antidepressant effects [2]. To date, no dosing guidelines or algorithms have been published by any group to aid anesthesiologists in achieving 15 minutes of 70-90% burst suppression with the administration of these drugs in human subjects.

We have developed a novel dosing recommendation algorithm that gives anesthesiologists an estimate of the levels of Propofol that they will need to administer to a patient to achieve 70-90% BSR for 12-15 minutes. This algorithm is based upon the Eleveld pharmacokinetic/pharmacodynamic (PK/PD) model of Propofol [3], with some adjustments. The objective of this study was to assess how well these dosing algorithms perform in giving recommendations that achieve the desired BSR in participants.

Methods: Following IRB approval and informed consent, each of 13 participants (69% female, 29-51 years old, 52-119 kg) underwent 3-6 treatments of high doses of Propofol. This analysis represents a retrospective look at these treatments. Two separate algorithms were used for dosing the first treatment and all subsequent treatments. For the first treatment of every participant, mean values for Ke0, Hill and EC50 from all treatments, except for those of the particular subject for whom the dosing recommendation was being made, were used to estimate the PK/PD behavior of the drug. For subsequent treatments, Ke0, Hill and EC50 parameters were estimated based on a log-log linear regression of the second-by-second observed BSR of the most recent past treatment to the effect site concentration predicted by the Eleveld model for that treatment. Based on these model parameters, an iterative approach was then used to find an estimated bolus and infusion rate for Propofol that would achieve a 70-90% BSR target range for 12-15 minutes for that participant.

To assess the effectiveness of these a priori dosing recommendations, they were compared to retrospectively determined ideal dosing levels. These ideal dosing levels considered were the actual administered bolus size and mean infusion rate that the anesthesiologist administered during the treatment.

Results: We found that there was a MdAPE of 21.6% with an interquartile range of 38.8% between the recommended prospective and the retrospective ideal infusion rate and a MdAPE of 18.2% with a 35.1% interquartile range between the recommended and ideal bolus.

Discussion: The error of prospective dosing recommendations before treatments when compared to ideal dosing levels made based on retrospective data collected after the treatment is considerable. However, the error lies well within the 20% to 30% range that is considered acceptable for MdAPE of PK models alone [4]. Limitations of our findings include that the findings result from a relatively small sample size of participants and represent a secondary analysis of data from a study that was not primarily designed as a PK/PD modeling study.

Conclusion: This dosing model represents an imperfect but useful first prototype for dosing Propofol during high-dose anesthetic treatments for depression.

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[4] *British Journal of Anaesthesia*, vol. 119, no. 5, pp. 918–927, Nov. 2017.

2022 STA Annual Meeting Abstract Winners
Excellence in Technology

Title: Processed electroencephalogram normative values in neonates

Presenting/First Author:
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2022 STA Annual Meeting Abstract Winners

Excellence in Technology

Introduction:
Electroencephalogram (EEG) monitors brain electrical activity that can reflect anesthetic depth. However, intraoperative proprietary EEG indices (e.g., BIS and PSI) originally developed from healthy adult volunteers are not reliable in infants and neonates, a population particularly sensitive to the effects of anesthesia.[1] Whereas raw unprocessed EEG can reliably detect "excessive" anesthesia in neonates, interpreting raw EEG requires advanced training and practice.[2] Besides proprietary EEG indices and raw EEG, there are other non-proprietary processed EEG (pEEG) parameters that can be used to determine anesthetic levels. However, there are no normative values for these non-proprietary pEEG parameters in unanesthetized infants that can be used for comparison to neonates under anesthesia. This study aims to address this knowledge gap by deriving normative values for pEEG parameters in unanesthetized neonates in awake and asleep states. The secondary aim is to determine the best pEEG parameters to discriminate between the different states of consciousness.

Methods:
This retrospective study included normal EEG recordings (14-channel neonatal bipolar montage) from healthy neonates, as interpreted by neurology and annotated into awake *vs* quiet asleep *vs* active sleep states. Since most intraoperative EEG monitoring use frontal channels, only frontal channels Fp1-C3 and Fp2-C4 were analyzed. EEG processing was performed using Matlab with NEURAL, a publicly available and validated library of Matlab functions.[3] After band-filtering between 0.5-30hz and artifact removal using the built in-function, the pEEG parameters listed in table 1 were calculated across 5 frequency bands (δ1: 0.5-1hz; δ2: 1-4hz; θ: 4-8hz; α: 8-13hz; ß: 13-30hz) for each EEG file. Mean and standard deviation (SD) were calculated for each channel and state (awake, quiet sleep, and active sleep) and paired 2-tailed Student's t-test were used to compare pEEG between states.

Results:
EEG from 23 neonates (mean [stdev] adjusted age on day of recording: 40.9 [1.97] weeks) were analyzed. The mean [stdev] of SEF 50/90 are listed in table 2. SEF 50 but not SEF 90 was able to differentiate between Awake vs Quiet and Awake vs Active. The power ratio, entropy, and coherence for each frequency band are listed in table 3. Power ratio can best differentiate between Awake vs Quiet and Awake vs Active best δ1 and θ bands. Conversely, entropy can best differentiate between the same states in ß bands. Finally, left/right coherence can differentiate between Awake vs Active best in δ2 band. None of the pEEG were able to differentiate between Active vs Quiet sleep states.

Conclusion:
This retrospective study provides normative pEEG values in neonates that will allow future researchers to compare to pEEGs obtained in neonates under anesthesia or sedation and provide direction on selecting pEEG parameters and frequency bands to best differentiate different states of consciousness.

Table 1:

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pEEG parameter	Definition	Changes with increased anesthetic depth
Spectral Edge Frequency 50	Frequency where 50% of the EEG power lies under.	Decreases
Spectral Edge Frequency 90	Frequency where 90% of the EEG power lies under.	Decreases
Power ratio (δ1,δ2,θ,α,ß)	% of power for each of 5 frequency band over total power	Increase in lower frequency bands
Coherence (δ1,δ2,θ,α,ß)	Synchrony between Left vs Right channels (0: no synchrony; 1: total synchrony)	Increases
Entropy (δ1,δ2,θ,α,ß)	Amount of randomness in EEG signals. (0: total order; 1: total randomness)	Decreases

Table 2:

			SEF 50 (hz)	SEF 90 (hz)
Fp1-C3	Awake	Mean	0.92	3.99
		Stdev	0.33	3.22
	Quiet Sleep	Mean	1.20	4.63
		Stdev	0.32	1.20
	Active Sleep	Mean	1.14	4.11
		Stdev	0.32	1.09
	Awake vs Quiet		**< 0.01**	0.38
	Awake vs Active		**0.03**	0.86
	Quiet vs Active		0.59	0.16
Fp2-C4	Awake	Mean	0.95	4.64
		Stdev	0.29	3.99
	Quiet Sleep	Mean	1.21	5.39
		Stdev	0.27	3.59
	Active Sleep	Mean	1.11	4.21
		Stdev	0.26	1.29
	Awake vs Quiet		**< 0.01**	0.52
	Awake vs Active		**0.05**	0.63
	Quiet vs Active		0.25	0.17

Table 3:

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Power ratio			δ1 %	δ2 %	θ %	α %	ß %
Fp1-C3	Awake	Mean	0.51	0.39	0.06	0.02	0.03
		Stdev	0.18	0.12	0.04	0.01	0.03
	Quiet Sleep	Mean	0.39	0.47	0.10	0.02	0.02
		Stdev	0.10	0.08	0.04	0.01	0.01
	Active Sleep	Mean	0.39	0.49	0.08	0.02	0.02
		Stdev	0.15	0.13	0.03	0.01	0.01
	Awake vs Quiet		**<0.01**	**0.02**	**<0.001**	0.1	0.16
	Awake vs Active		**0.02**	**0.01**	**0.03**	0.28	0.14
	Quiet vs Active		0.93	0.57	0.09	0.52	0.98
Fp2-C4	Awake	Mean	0.47	0.42	0.06	0.02	0.03
		Stdev	0.14	0.10	0.03	0.01	0.03
	Quiet Sleep	Mean	0.37	0.48	0.10	0.02	0.03
		Stdev	0.09	0.06	0.04	0.01	0.04
	Active Sleep	Mean	0.39	0.49	0.08	0.02	0.02
		Stdev	0.13	0.11	0.03	0.01	0.01
	Awake vs Quiet		**<0.01**	**0.02**	**<0.001**	0.09	0.47
	Awake vs Active		0.06	**0.04**	**0.04**	0.28	**0.05**
	Quiet vs Active		0.6	0.72	0.08	0.53	0.49
Entropy							
Fp1-C3	Awake	Mean	0.93	0.84	0.96	0.98	0.98
		Stdev	0.06	0.09	0.02	0.01	0.02
	Quiet Sleep	Mean	0.98	0.90	0.96	0.98	0.94
		Stdev	0.03	0.04	0.01	0.01	0.03
	Active Sleep	Mean	0.97	0.89	0.96	0.98	0.95
		Stdev	0.04	0.06	0.01	0.01	0.02
	Awake vs Quiet		**<0.001**	**<0.01**	0.24	0.09	**<0.001**
	Awake vs Active		**<0.01**	**0.05**	0.34	0.49	**<0.001**
	Quiet vs Active		0.3	0.4	0.77	0.22	0.51
Fp2-C4	Awake	Mean	0.95	0.86	0.95	0.98	0.98
		Stdev	0.04	0.07	0.02	0.02	0.02
	Quiet Sleep	Mean	0.98	0.90	0.96	0.98	0.95
		Stdev	0.03	0.04	0.01	0.01	0.02
	Active Sleep	Mean	0.96	0.89	0.96	0.98	0.96
		Stdev	0.04	0.05	0.01	0.01	0.02
	Awake vs Quiet		**<0.01**	**<0.01**	0.06	0.91	**<0.001**
	Awake vs Active		0.2	0.07	0.06	0.95	**<0.001**
	Quiet vs Active		0.12	0.43	0.94	0.78	0.18
Coherence							
	Awake	Mean	0.35	0.36	0.27	0.3	0.33
		Stdev	0.25	0.20	0.19	0.27	0.24

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Fp1-C3/ Fp2-C4	Quiet Sleep	Mean	0.41	0.48	0.33	0.28	0.21
		Stdev	0.18	0.16	0.15	0.15	0.15
	Active Sleep	Mean	0.46	0.56	0.4	0.34	0.39
		Stdev	0.19	0.18	0.25	0.32	0.35
	Awake vs Quiet		0.39	**0.03**	0.29	0.7	**0.04**
	Awake vs Active		0.11	**<0.001**	0.07	0.66	0.54
	Quiet vs Active		0.38	0.14	0.27	0.42	**0.04**

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Honorable Mention

THE DEVELOPMENT OF NON-CONTACT 'TOUCHLESS' MONITORING OF RESPIRATORY RATE

Presenting Author: Paul S. Addison, PhD, Distinguished AI and Data Scientist.
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Introduction: The measurement of respiratory physiological parameters is ubiquitous in the hospital setting. Of these, respiratory rate (RR) is the most prevalent and often forms an essential component of many early warning clinical scoring systems [1]. Changes in RR are often one of the earliest and more important indicators that precedes major complications such as respiratory tract infections, respiratory depression associated with opioid consumption, anesthesia and/or sedation, as well as respiratory failure [2–4]. Here, we report on the performance of a depth-sensing camera system [5] for the continuous non-contact 'touchless' monitoring of Respiratory Rate (RR).

Method: Six healthy subjects undertook a range of breathing rates from 4 to 40 BrPM. These were set rates of 4, 5, 6, 8, 10, 15, 20, 25, 30, 35 and 40 BrPM. In total, 265 separate rates were captured across a range of conditions including posture (prone, supine, lateral), position (center and edge of bed) and coverings (no sheets, sheets, duvet). An Intel D415 depth camera was used to acquire depth information from a field of view centered on the subject torso. This data was processed to extract the localized depth-changes within the torso region of the subject corresponding to respiratory activity. This was further processed to produce a respiratory rate RR_{depth} output once-per-second from the device. RR_{depth} was compared to a capnograph reference, RR_{capno}.

Results: Figure 1 contains a bubble plot of RR_{depth} versus RR_{capno} for all subjects and tests. An RMSD of 1.74 BrPM (mean bias of -0.13 BrPM) was achieved across the target RR range of 4-40 BrPM.

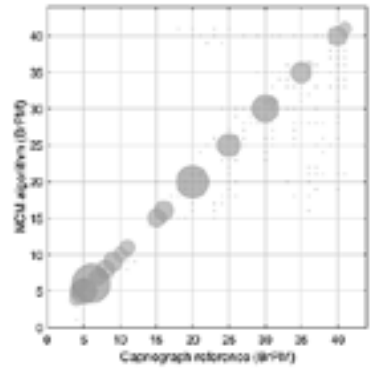

Figure 1: Bubble plot of RR_{depth} vs RR_{capno}. Bubble size is proportional to the number of cases.

Conclusions: These early-stage results are encouraging and exhibit similar accuracies to earlier studies we have conducted [6,7]. However, the current results extend over a much wider range than those previous studies. We believe that "non-contact", or "touchless", monitoring has great potential for the future. We continue to iterate on our algorithm to improve its performance and robustness.

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