DEPARTMENT OF ANESTHESIA AND PERIOPERATIVE MEDICINE

SLEEPY TIMES

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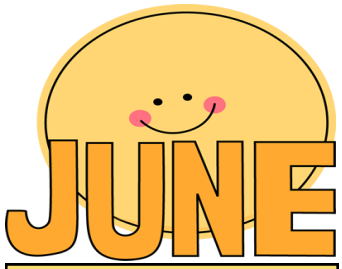


Inside This Issue:

MESSAGE FROM THE CHAIRMAN: THE CLASS OF 2020

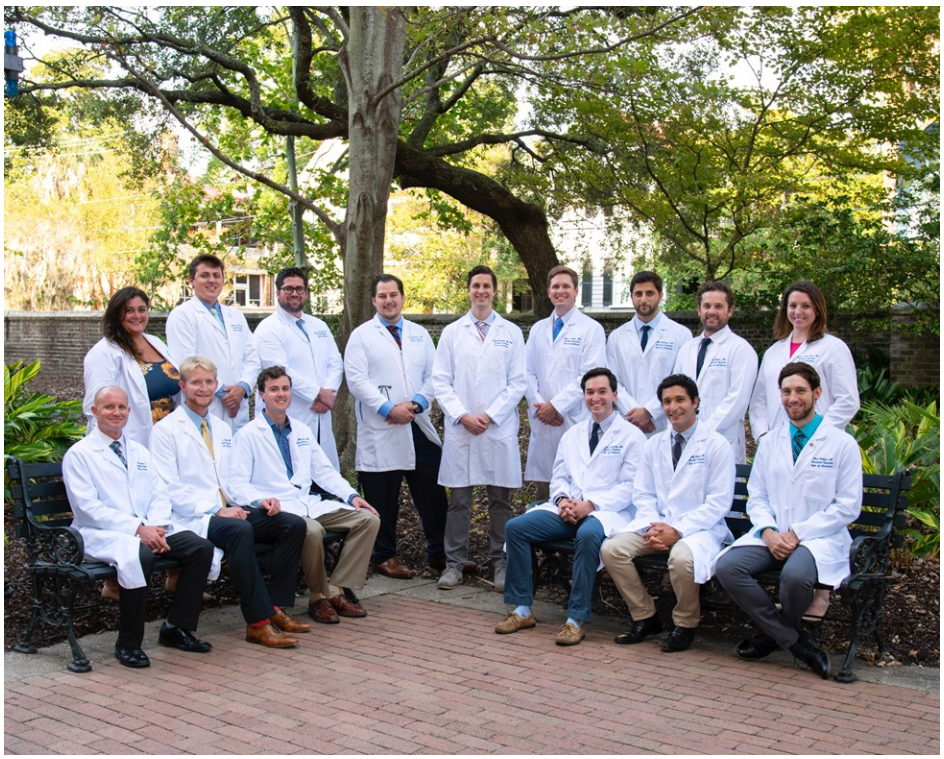
Each July, I utilize my opening statement to highlight my remarks from the resident and fellow graduation event that occurs toward the end of June. Interesting, 2020 has been anything but normal. As we slowly begin to restart from the COVID 19 shutdown, many questions remain. What will the new normal look like? When will we be able to congregate in larger groups? Will there be a second wave?

These unknowns have resulted in the inability to have a large graduation event for the 2020 class. Despite this setback, GJ and I are planning smaller and more intimate events with our residents and fellows. I want to recognize them in June to allow all of the department the opportunity to say goodbye.

This group of seniors have been remarkable in their dedication to our patients, department and each other. They have willingly accepted and, in many cases, volunteered to take on the toughest of duties during the COVID 19 pandemic. They have formed COVID intubation teams and created the new term of "dofficer" to assure that we provided the best care possible to our patients while minimizing infectious risks to each other. They have accepted with grace the constant changes to their call schedules when on short notice we needed to increase in house manpower first at ART to cover the OB explosion and later in our ICUs as the department prepared for a potential COVID 19 surge. The COVID 19 pandemic is and will be a defining event in your medical careers and personal lives. I along with the whole faculty and department want to thank you. You will not be forgotten.

You came from throughout the country, and we will be sending you out again shortly as you represent the best of MUSC. I hope you do not mind me sharing where you will be going in July.

As we go through the month of June, I would welcome the whole department laughing and maybe crying with you as we remember our time with you over the last four years.



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MESSAGE FROM THE CHAIRMAN CONTINUED…

LAST NAME	FIRST NAME	Post-Graduation Plans
Dahl	Kirsten	Anesthesiologist at Self Regional Medical Center in Greenwood, SC
Foret	Clayton	Anesthesiologist at East Carolina Anesthesia Associates, Greenville NC
Vega	Hannah	Anesthesiologist at University of Tennessee Medical Center in Knoxville, TN
Hopkins	Daniel	Intensivist/Anesthesiologist at Oklahoma Heart Institute in Tulsa, OK
Stubblefield	Jonathan	Anesthesiologist at American Anesthesiology in Chattanooga, Tennessee
Antonovich	Devin	Pain Medicine Fellow at The Medical College of Georgia in Augusta, GA.
Draper	Kevin	Anesthesiologist at Anesthesia Associates of Tallahassee in Tallahassee, FL
Gama	Willy	Chronic Pain Fellow at UPMC in Pittsburgh, PA
Gerughty	Andrew	Anesthesiologist with NorthStar Anesthesia in Louisville, KY
Green	John	Pediatric Anesthesiology Fellow at MUSC in Charleston, SC
Gukasov	Mamikon	Anesthesiologist at MUSC in Charleston, SC
Hynes	Sean	Anesthesiologist at Columbia Anesthesia Group in Portland, Oregon
Jeanes	Zachary	Pediatric Anesthesiology Fellow at Vanderbilt University in Nashville, TN
Kelly	Tara	Regional Anesthesiology Fellow at MUSC in Charleston, SC
King	Martha Anne	Attending Anesthesiologist at Advent Health in Tampa, FL
Mims	Ryan	Anesthesiologist at Prisma Health Baptist in Columbia, SC
Phillips	Maxie	Critical Care Anesthesiology Fellow at MUSC
Sealy	Clark	Regional Anesthesiology Fellow at the University of Colorado in Denver, CO.
Wharton	Jeffrey	Pediatric Anesthesiology Fellow at Emory University in Atlanta, GA
Wolla	Christopher	Regional Anesthesiology Fellow at MUSC in Charleston, SC

ANNUAL MANDATORIES

Annual Mandatories

1) Conflict of Interest: https://web.musc.edu/about/coi

Due by ASAP

2) MyQuest – MUSC General Mandatories + MUSC Health Mandatories

Extended to 9/30/2020

2020 MUSC General Mandatories
(Enterprise-wide)

- Active Shooter
- Code of Conduct and HIPAA
- Crime Prevention and Jenne Cleary Act Training
- Family Educational Rights and Privacy Act (FERPA)
- Information Security
- OSHA Review
- Prohibited Discrimination and Harassment
- Tuberculosis (**Charleston only**)

2020 MUSC Health Mandatory Training
(MUSC Health Care Team Members Only)
Charleston, Florence and Lancaster Divisions

- MUSC Health General Compliance (includes billing)
- Culture of Safety
- Emergency Management Campus Security
- Infection Control for Healthcare Workers
- Meeting the Unique Care Needs of Patients
- MR Safety for Healthcare Workers
- Stroke & Heart Early Recognition
- Workplace Violence

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RESEARCH CORNER

REVIEW ARTICLE

HENDRICKSE ET AL.

Service Requirements of Liver Transplant Anesthesia Teams: Society for the Advancement of Transplant Anesthesia Recommendations

Adrian Hendrickse,[1] Cara Crouch,[1] Tetsuro Sakai,[2] William D. Stoll,[3] Monica McNulty,[4] Evan Pivalizza,[5] Srikanth Sridhar,[5] Geraldine Diaz,[6] Patricia Sheiner,[7] Moises I. Nevah Rubin,[8] Ali Al-Khafaji,[9] James Pomposelli,[10] and M. Susan Mandell[1]

[1]Department of Anesthesiology, University of Colorado, Aurora, CO; [2]Department of Anesthesiology, University of Pittsburgh, Pittsburgh, PA; [3]Department of Anesthesia and Perioperative Medicine, Medical University of South Carolina, Charleston, SC; [4]Adult and Child Consortium for Health Outcomes Research and Delivery Science, Anschutz Medical Campus, University of Colorado, Aurora, CO; [5]Department of Anesthesiology, UTHealth McGovern Medical School, Houston, TX; [6]Department of Anesthesiology, SUNY Downstate Medical Center, State University of New York, Brooklyn, NY; [7]Department of Surgery, Hartford Hospital, Hartford, CT; [8]Department of Medicine, University of Texas, Houston, TX; [9]Department of Critical Care Medicine, University of Pittsburgh, Pittsburgh, PA; and [10]Department of Surgery, University of Colorado, Aurora, CO

Dr. William D. Stoll

Instillation of 5% Povidone-Iodine Ophthalmic Drops Decreases the Respiratory Rate in Children Undergoing Strabismus Surgery: A Randomized Controlled Trial

Michelle S. Rovner, MD; Bethany Jacobs Wolf, PhD; Melanie Rubin, BS; Alexandra Ritter, BS; Christopher L. Heine, MD; Tracy E. Wester, MD; Cory M. Furse, MD, MPH, FAAP

ABSTRACT

Purpose: To investigate the effects of topical application of ophthalmic 5% povidone-iodine eye drops, which has been reported to cause apnea in spontaneously breathing children during general anesthesia.

Conclusions: Topical application of 5% povidone-iodine eye drops causes a slowing and pause in spontaneous ventilation in a majority of children prior to strabismus surgery. This may represent activation of the diving reflex.

[*J Pediatr Ophthalmol Strabismus*. 2019;56(6):378-382.]

Dr. Michelle Rovner

Dr. Christopher Heine

Dr. Tracy Webster

Dr. Cory Furse

Dr. Bethany Wolf

RESEARCH CORNER CONTINUED...

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journal homepage: www.elsevier.com/locate/jclinane

Anesthetic challenges and outcomes for procedures in the intraoperative magnetic resonance imaging suite: A systematic review

Hedwig Schroeck (M.D.)[a,b,*], Tasha L. Welch (M.D.)[c], Michelle S. Rovner (M.D.)[d], Heather A. Johnson (M.L.I.S.)[e], Florian R. Schroeck (M.D., M.S.)[a,f,g]

[a] Geisel School of Medicine at Dartmouth College, 1 Rope Ferry Road, Hanover, NH 03755, USA
[b] Department of Anesthesiology, Dartmouth-Hitchcock Medical Center, 1 Medical Center Drive, Lebanon, NH 03756, USA
[c] Department of Anesthesiology and Perioperative Medicine, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, USA
[d] Department of Anesthesia & Perioperative Medicine, Medical University of South Carolina, 165 Ashley Avenue, Suite 525CH, Charleston, SC 29425, USA
[e] Biomedical Libraries, Dartmouth College, 1 Medical Center Drive, Lebanon, NH 03756, USA
[f] White River Junction VA Medical Center, 215 N Main Street, White River Junction, VT 05009, USA
[g] The Dartmouth Institute for Health Policy and Clinical Practice, Geisel School of Medicine at Dartmouth College, USA

Dr. Michell Rovner

ARTICLE IN PRESS

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ELSEVIER
www.obstetanesthesia.com

ORIGINAL ARTICLE

Maternal and procedural factors associated with estimated blood loss in second trimester surgical uterine evacuation: a retrospective cohort analysis

K.H. Bridges,[a] B.J. Wolf,[b] A. Dempsey,[c] W.B. Ellison,[d] D.Y. Williams,[e] S.H. Wilson[e]
[a] Department of Anesthesia and Perioperative Medicine, Medical University of South Carolina, Charleston, SC, USA
[b] Department of Public Health Sciences, Medical University of South Carolina, Charleston, SC, USA
[c] Department of Obstetrics and Gynecology, Medical University of South Carolina, Charleston, SC, USA
[d] College of Medicine, Medical University of South Carolina, Charleston, SC, USA
[e] Department of Anesthesia and Perioperative Medicine, Medical University of South Carolina, Charleston, SC, USA

Dr. Kathryn Bridges

Dr. Silvia Wilson

DEPARTMENT CHAMPIONS

Champion # 18 May 4, 2020 - Dr. Eric Bolin

I would like to nominate Dr. Eric Bolin as our department COVID champion. He led the charge with getting the COVID testing status and date onto our Status boards and many other boards throughout our hospitals. It will likely also be used at the Regional Hospitals as well. This was a great idea and will be extremely helpful for the weeks/months ahead. We are all grateful for your efforts.

Image	Meaning
	Test Result "Negative" or "Not Detected"
	Test Result "Positive"
	Testing is in "Active" mode, pending result
	Status Unknown (no discrete Epic result recorded or active MUSC test order-may still include scanned outside test results)

Champion # 19 May 5, 2020 - Townsend Langley

Townsend Langley has been a great leader for the administrative staff. Working from home can feel isolating, but she has done a great job keeping us connected. She has always made an effort to not only keep us updated and informed, but making sure we feel motivated and inspired (especially during these difficult times). Townsend is always ready to listen to our ideas and concerns. She is a wonderful manager, and we are lucky to have her as our team leader! Thank you Townsend for leading by example….

Champion # 20 May 6, 2020 - Dr. Carlee Clark

I would like to nominate Dr Carlee Clark as a COVID leader for her tireless efforts. In the last month, Dr. Clark has strived to keep the department safe and informed. She has met with leaders in perioperative nursing, numerous surgical and medicine departments, infectious disease, and the ICU in order to make sure that our department had both a strong voice and a robust plan for COVID-19. Notably, she did this while calling the attention to the efforts of others, serving her own weeks in the ICU, and leading endless Webex meetings to plan and strategize. Although many of us are quick to point out things Dr. Clark may have missed, she is equally as fast to thank us for our comments. I hope we as a department can join together to thank her all efforts and energy. Congratulations!

Champion # 21 May 7, 2020 - Department Residents

Today's department champions go to our residents. The past 8 weeks have been one of constant change. The residents have experienced substantial modification of their training experiences. Despite frequent changes to their call schedules, work routines and lecture series, they have performed with the upmost professionalism. We owe them our gratitude. Today, I want to give a special thanks to our residents.

Champion # 22 May 8, 2020 - All Care Providers

The champion I would nominate is the care providers...the teams that have been on the front, actually doing the cases and caring for patients every single day. The provider who puts their face in the airway of another human being wearing a garbage bag and a home made shield and a retrofitted mask...not knowing for sure if the PPE really functions properly. The provider who has adapted to daily, sometimes 2-3 times a day changes in the rules, protocols and routines and does it with a smile. The provider who has flexed their hours, come in late, stayed late and changed their schedule to help make it work for everyone. The provider who holds the hand of an afraid and lonely patient with no family to help them through, even though they are afraid and lonely too.

Here's to the front of the line heroes. None of us would be here without them.

COVID-19 Resiliency Clinic
Sleep and Anxiety Treatment and Research Program Department of Psychiatry and Behavioral Sciences Medical University of South Carolina

Responding to the COVID-19 pandemic in our community can have a significant impact on MUSC healthcare providers. Stress management and fostering resilience is essential to our well-being, and to our ability to provide ongoing care. The Department of Psychiatry and Behavioral Sciences will be offering resources and services to MUSC/MUSC Health faculty and employees that have been emotionally affected by COVID-19.

In addition to current resources of MUSC's Employee Assistance Program (EAP), the newly established COVID-19 Resiliency Clinic embedded within the Sleep and Anxiety Treatment and Research Program will provide individual brief telehealth interventions to help MUSC healthcare providers in bolstering resilience as they provide care to COVID-19 patients. Further, the COVID-19 Resiliency Clinic will offer regular virtual webinar workshops to offer information about stress management strategies, coping, and fostering a self of well-being during this challenging time.

Resiliency Resources from MUSC

COVID-19 Resiliency Clinic

Healthcare workers across MUSC who are responding to and caring for COVID-19 patients within our community are at increased risk of stress related difficulties. Developing strategies to bolster resilience in order to continue to respond effectively is essential for the health and well-being of our healthcare team. Below are several resources that have been compiled to assist in taking care of yourself and those around you during these challenging times.

Available MUSC resources:

COVID-19 Resiliency Clinic

MUSC, MUHA, and MUSC-P faculty and staff can be seen for free brief COVID-19 specific stress management and resiliency bolstering coping strategies within one to four individual telehealth clinical support sessions. These sessions will focus on learning tools to manage and cope with stressors related to COVID-19 care. Contact: Dr. Melissa Milanak milanak@musc.edu 843-792-0042

Sleep and Anxiety Research and Treatment Center

MUSC, MUHA, and MUSC-P faculty and staff are offered individual evidence based cognitive behavioral therapy and medication management currently via telehealth for sleep and anxiety related difficulties. Contact: Dr. Melissa Milanak milanak@musc.edu 843-792-0042

MUSC Employee Assistance Program (EAP)

MUSC, MUHA, and MUSC-P faculty and employees and their families can be seen for free, short term counseling. An operator is available 8:30am-5:00pm, sessions are by appointment only. Contact: Jeni Bowers-Palmer bowersj@musc.edu 843-792-2848

MUSC Chaplaincy/ Pastoral Care Services

On-site service is available 24/7. Contact: Call 792-9464 or Page (Main: 18089; ART: 17265; SJCH: 17075)

Recommended reading resources for healthcare providers in managing distress related to COVID-19:

Center for Disease Control: Emergency Responder Tips for Taking Care of Yourself (CDC) Managing Anxiety and Stress (CDC)

Uniformed Services University – Center for the Study of Traumatic Stress: Facts sheets for Providers, Families, Leaders

American Psychiatric Association: APA Resources for Providers, Families and Healthcare Leaders https://www.psychiatry.org/psychiatrists/covid-19-coronavirus

American Psychological Association: Seven Research Findings that can help People Deal with COVID-19

American Foundation for Suicide Prevention: Protecting your Mental Health During the Coronavirus Outbreak

Recommended reading resources for guidance on talking to (your) family about COVID-19:

The American Academy for Child and Adolescent Psychiatry:
AACAP Coronavirus Resources for Parents, Youth and Clinicians

National Child Traumatic Stress Network, NCTSN:
Taking Care of Family Well-Being

Recommended apps to assist in learning and practicing mindfulness strategies:

Headspace (currently free for heathcare providers with NPI)
https://www.headspace.com/health-covid-19

Insight Timer
www.insighttimer.com

Calm
www.calm.com

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Medical University of South Carolina
Changing What's Possible

Inventor of Pulse Oximetry; Takuo Aoyagi died on April 18 at the age of 84. A special article was published in 2007 in *Anesthesia Analgesia* on this remarkable discovery.

Takuo Aoyagi: Discovery of Pulse Oximetry

John W. Severinghaus, MD

In the 1930s and 1940s, photo cells permitted German, English, and American physiologists to construct ear oximeters with red and infrared light, requiring calibration. In 1940 Squire recognized that changes of red and infrared light transmission caused by pneumatic tissue compression permitted saturation to be computed. In 1949 Wood used this idea to compute absolute saturation continuously from the ratios of optical density changes with pressure in an ear oximeter. In 1972 Takuo Aoyagi, an electrical engineer at Nihon Kohden company in Tokyo, was interested in measuring cardiac output noninvasively by the dye dilution method using a commercially available ear oximeter. He balanced the red and infrared signals to cancel the pulse noise which prevented measuring the dye washout accurately. He discovered that changes of oxygen saturation voided his pulse cancellation. He then realized that these pulsatile changes could be used to compute saturation from the ratio of ratios of pulse changes in the red and infrared. His ideas, equations and instrument were adapted, improved and successfully marketed by Minolta about 1978, stimulating other firms to further improve and market pulse oximeters worldwide in the mid 1980s. Dr. Aoyagi and associates provided a detailed history for this paper.

(Anesth Analg 2007;105:S1–4)

OXIMETRY HISTORY

Karl von Vierordt (Tübingen, 1876) measured the rate of spectral changes of light penetrating tissue when circulation was interrupted. His work was ignored until Ludwig Nicolai (Göttingen, 1931) repeated that study. Nicolai's device measured red light transmission through a hand. In 1939 Karl Matthes in Leipzig introduced ear oximetry, counterbalancing red and infrared light. J. R. Squire (London, 1940) was the first to realize that the differences of transmission of red and infrared light before and after expelling the blood from the web of the hand with a pressure cuff was a function of saturation (1). Pulse oximetry may be regarded as a sequel to Squire's device and idea, using pulsatile changes in tissue blood volume instead of compression vascular collapse.

Oximetry development was stimulated during WW II in an effort to warn military pilots of dangerous hypoxia. Glen Millikan (1906–1947) developed a lightweight red and infrared ear oximeter in 1942 for which he coined the word "oximeter" (2).

Earl Wood (Mayo Clinic, 1949) and his PhD student, J. E. Geraci, modified the Millikan ear piece by incorporating Squire's pneumatic cuff. Wood extended and mathematically developed the ideas of Squire, plotting the ratio of the ratio of red to infrared light optical ear density produced by compression and reperfusion as a unique function of saturation (3). After setting gains with the bloodless ear, Wood divided the decreased red signal by the decreased infrared signal to obtain saturation without calibration. However, in practice, users often set the signal to 100% while the subject breathed oxygen.

AOYAGI AND HIS PULSE OXIMETER

Takuo Aoyagi was born on February 14, 1936, in Niigata Prefecture, Japan, and graduated in 1958 from the Faculty of Engineering at Niigata University with a degree in electrical engineering. Initially he worked at Shimadzu, a scientific instrumentation company.

In February 1971 he joined the Research Division of Nihon Kohden Corporation. Initially his dream was to make a sensor of blood oxygen saturation to signal the need for artificial ventilation, and to accomplish this he studied the oximetry literature. Impressed with Wood's plot of red and infrared light hemoglobin density (3), he obtained and studied a Japanese version (Erma) of Wood's oximeter earpiece. He concluded that an ear oximeter could be used to record a dye dilution curve, but would require calibration with a blood sample. Because arterial pulsatile "noise" prevented accurate recording of the dye clearance, he invented a method to eliminate this noise, which led to his discovery. He wrote of this work in 2003 (4):

"These [variations due to the pulse] prevented accurate extrapolation of the down-slope of the dye curve after recirculation begins. I investigated this problem mathematically using the Lambert-Beer law. Then I conceived the idea of eliminating the pulsation

From the Department of Anesthesia, University of California San Francisco, San Francisco, California.

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Address correspondence and reprint requests to John W. Severinghaus, PO Box 974, Ross, CA 94957. Address e-mail to jwseps@comcast.net.

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ARTICLE: INTERNATIONAL ANESTHESIA RESEARCH SOCIETY CONTINUED…

by computing the ratio of optical densities of the two wavelengths. This supposition was proved workable by experiments."

The Key Idea: The Ratio of Ratios

While testing this way of canceling out the pulsations in the ear dye densitometer, Aoyagi observed that, by holding his breath, a decrease of oxygen saturation reintroduced pulsatile waves by changing the ratio of densities at the two wavelengths. This led him to predict that this artifact might be used to measure arterial oxygen saturation. He continues:

"At this point I realized that both the pulsating portion and non-pulsating portion of optical densities of the blood in tissue must have the same information of blood color. And I imagined as follows:

(1) If the optical density of the pulsating portion was measured with two appropriate wavelengths and their ratio was obtained, the result must be same as Wood's ratio.
(2) In this method the arterial blood is selectively measured and the venous blood does not affect the measurement. Therefore the probe site is not restricted to the ear.
(3) In this method the reference (comparable to the blanched ear reference) is set with each pulse.

Therefore a probe shift of location, or motion introduces only a brief artifact, before quickly returning to normal measurement. This was my conception of the pulse oximeter principle in December, 1972."

He confirmed both theoretically and experimentally the validity of Wood's plot of the density ratios. Aoyagi called the ratio of ratios ϕ:

$$Spo_2 = f\phi$$

where

$$\phi = (AC_{red}/DC_{red})/(AC_{IR}/DC_{IR})$$

where AC and DC symbolize the pulsatile and non-pulsatile components of the transmitted light.

Greatness in science often, as here, comes from the well-prepared mind turning a chance observation into a major discovery. "One man's noise is another man's signal" commented the respiratory physiologist Jere Mead half a century ago.

Development of the Oximeter

Aoyagi tested various wavelengths and methods of implementing the pulse oximetry idea. He selected the 630-nm wavelength, at which red light absorption was most sensitive to oxygen saturation, and he balanced this against a 900-nm infrared wavelength, which is not absorbed by dye. Indo-cyanine green dye was selected for cardiac output measurement because its absorption peaks at 805 nm, the isobestic point where hemoglobin and oxyhemoglobin have equal absorption, making dye dilution curves independent of saturation. Aoyagi noted that blood optical density at 900-nm decreased with desaturation, resulting in a larger signal than provided by ratios at 630 and 805 nm.

In early 1973, Aoyagi's supervisor, Y. Sugiyama, told Dr. Susumu Nakajima, a surgeon then working at the Sapporo Minami National Sanatorium, of Aoyagi's pulse oximetry invention. Nakajima, understanding that the method was a secret to be kept, placed an order with Nihon Kohden for the as-yet-undeveloped apparatus.

Aoyagi wrote (4):

"I assigned Mr. Michio Kishi chief of this project. For this pilot model, components of the dye densitometer were used. The light source was a small tungsten lamp. The transmitted light was divided into two and each [beam] was received with combination of an interference filter and a phototransistor. I used wavelengths of 630nm and 900nm. I selected 900 nm to avoid interference by [the dye] ICG. From the transmitted light, pulsation amplitude 'AC' and the total 'DC' were obtained and the ratio AC/DC was calculated. This AC/DC ratio was obtained at the two wavelengths and their ratio, phi (ϕ) was calculated. This ϕ was expected to correspond to Sao_2."

"For both dye densitometry and pulse oximetry, it was necessary to have a theoretical base of scattering optics.[1] Dr. Kazuo Shibata of Tokyo Institute of Technology had been studying for many years methods of measurement of pigments in plants *in vivo*. I read his papers and consulted with him regarding the state-of-the-art. The only way to decrease the effect of error sources was to use one or two scattering plates. This method was called the "opal-glass method". We adopted this method. By late 1973 the oximeter was ready and clinical evaluation was conducted in Sapporo."

Disclosure of the Invention

Aoyagi reported his discovery of pulse oximetry to the Japanese Society of Medical Electronics and Biologic Engineering (MEBE) on April 26, 1974 (5) and published with his many collaborators (6). On March 29, 1974, a patent application titled "Apparatus for Photometric Blood Analysis" was submitted to the Japanese Patent Office by the Nihon Kohden Corporation, naming Aoyagi and Kishi as inventors. This patent was publicly disclosed on October 9, 1975, and published on August 2, 1978 (No. 53-26437); Patent 947714 was granted on April 20, 1979.

Competitor

On April 24, 1974, two days before the MEBE meeting, a patent application also describing the use of the arterial pulse for oximetry was submitted by Masaichiro Konishi and Akio Yamanishi, named as

[1]The experimental ratio of ratios deviates from theory due largely to scattering by tissue. Aoyagi has sought and identified ways of minimizing this error.

ARTICLE: INTERNATIONAL ANESTHESIA RESEARCH SOCIETY CONTINUED...

inventors working at the Minolta Camera Company. This remarkable simultaneity of discovery led me, in reviewing this history, to inquire about the possibility that the secret was discovered in Aoyagi's submitted abstract in advance of the meeting. Aoyagi wrote (personal communication, September, 2006):

"For presentation at MEBE, a preliminary abstract had to be submitted in the fall. In October, 1973, I submitted an application for a presentation, with a short explanation of the pulse oximeter principle. Many referees checked them and perhaps almost all of them were allowed to submit abstracts. My preliminary abstract was very short, but the [pulse oximeter] idea was written in it.[2] The application was accepted."

In January 1974, Aoyagi submitted to MEBE the complete abstract describing the invention.

Aoyagi continued:

"Yamanishi is familiar to me because [several years later, and while employed by their different companies] we two worked together to try to make a pulse oximeter calibrator using real blood, at the request of Dr. K. Miyasaka (then head of anesthesia at National Children's Hospital, Tokyo). Recently Yamanishi wrote a historical story of the pulse oximeter for the Japanese Society of Medical Instrumentation and it was published (7)."

In November 2006, at my request, Yamanishi shared his records and memories of these events with me [personal communication]. In the Fall of 1973, he was given a copy of Wood's oximeter chapter (3) by his supervisor Konishi. Yamanishi had been interested in the operation of blanching and refilling the blood in the earlobe. He had been studying photo plethysmography for a year, particularly the work of Takeda et al. of Nippon Medical School (Tokyo) (8). He was aware of the effect on optical signal ratios of change of thickness of arterial blood in the tissue. In his 2005 review of events of 30 years past (7) he wrote (translation by Aoyagi): "In January, 1974, Yamanishi made up an idea of pulse oximeter and handed to a person in charge of patent saying 'This is big invention.'"[3]

He thought that combining the idea of varying tissue blood volume with the larger signal of the finger would permit measurement of oxygen saturation. In April 1974 shortly before the 13th Conference of MEBE, Yamanishi noticed Aoyagi's abstract on the pulse oximeter. He was surprised that his own group [Minolta] had only developed the theory, whereas Aoyagi et al. had already constructed an experimental model. Urged by Konishi and Yamanishi, Minolta's patent section submitted the document to the Japanese patent office on 24th April, hoping to establish their claim before more information was disclosed in the conference. The Japanese Patent Office rejected Konishi's patent application in 1982. In the United States, Minolta applied for and obtained patent protection with limited effect, being based on a subsequent Minolta patent in Japan.

Aoyagi's prototype pulse oximeter was tested in conjunction with Dr. Nakajima in Sapporo on September 6 and 7, 1973 and by Nakajima and his associates on February 5 to 7, 1974 (9). It used an earpiece with incandescent light, filters, and photo transistors. However, Nihon Kohden did not continue to develop or market this instrument and made no effort to patent it abroad. Aoyagi was transferred to a post as assistant manager in the patient monitoring division of Nihon Kohden in September of 1975, and the research and development of the pulse oximeter was assigned to another worker. The pulse oximeter subsequently was marketed, but its performance was not satisfactory.

The Minolta Company developed Yamanishi's oximeter concept using a fingertip probe to take advantage of the greater pulse amplitude. Light sources and signals were conducted through fiberoptic cables to and from the instrument, as was done in the Shaw-Hewlett Packard multiwavelength ear oximeter. Minolta's device was marketed in 1977 as the Oximet MET-1471. Its response to hypoxia was reported to be linear and accurate to within 5% by Suzukawa et al. in 1978 (10) and Yoshiya et al. in 1980 (11). Nakajima and associates used it clinically in 1979 (12). However, when studied at Stanford in 1980 by Sarnquist et al. (13) a Minolta model 101 [identical to Oximet MET-1471] seriously underestimated the severity of hypoxia: At 50% actual Sao_2 it read about 70%. Yamanishi wrote me (personal communication, 2006): "The Sarnquist data was the very important trigger for us to improve the accuracy of our pulse oximeter." In 1984, Y. Shimada (then anesthetist of Osaka University, now professor of Nagoya University) with Minolta's K. Hamaguri, I. Yoshiya, and N. Oka (14) published data using a Minolta Oximet MET-1471 that agreed with Sarnquist's evidence of under-reporting the degree of desaturation. In this paper, this group developed perhaps the first theory of pulse oximetry that included scattering effects by blood cells.

Aoyagi wrote (personal communication):

"Although it was a rather too simple a theoretical formula, it encouraged me to build up my theoretical formula. There was a big difference between Minolta and Nihon Kohden. In Nihon Kohden the idea of pulse oximeter was denied by the person in charge of optical plethysmography. After my shift to another position, Nihon Kohden made no improvement in pulse oximeter technology until world-wide spread of Nellcor's oximeters. On the contrary, Minolta made up a highly accurate instrument using their excellent optical technology, and later even made a model change before Nellcor. I appreciate Minolta. Without their recognition of idea of pulse oximeter, the idea might be buried."

[2]Konishi was on the MEBE board and may have seen Aoyagi's notes.

[3]This was, as far as I know, Yamanishi's first mention in print (7) that he had had the idea in January 1974 of using the arterial pulse to generate the AD/DC variations.

ARTICLE: INTERNATIONAL ANESTHESIA RESEARCH SOCIETY CONTINUED…

Finally, in September 1985, Aoyagi was permitted to resume research and development of his pulse oximeter. His subsequent work has focused on the mechanism causing the nonlinearity of the Beer's law relationship of light transmission to saturation. He developed the theoretic background for both pulse oximetry and later for use of multiple wavelengths for other clinically useful purposes. His pulse spectrophotometer permits determination of plasma volume, hepatic blood flow and cardiac output after dye injection.

Aoyagi was granted the degree of Doctor of Philosophy in Engineering at Tokyo University on December 1993. He was awarded two prizes in 2002. The "Social" award was given for research other than on anesthesiology by the Japanese Society of Anesthesiologists. The Purple Ribbon Medal was given him by the Emperor of Japan for contributions to sciences and arts. Nihon Kohden was then persuaded to allow him to continue his research after retirement.

CONCLUSION

Introduction of pulse oximetry coincided with a 90% reduction in anesthesia-related fatalities. Takuo Aoyagi's invention was serendipitous. Although he could use the infrared signal to cancel pulsatile "noise" in the dye decay optical signal, hypoxic desaturation spoiled the smooth dye curve. In that noise, he recognized a useful signal—oximetry—because his mind was well prepared to understand what he saw happen. The process of turning his insight into more accurate, convenient and inexpensive saturation monitors still continues in dozens of laboratories and firms, while he continues to innovate.

Author's Postscript

In 1985, I was asked by Professor J. Payne to present the history of pulse oximetry to a meeting in the United Kingdom, later published (15). Using only published literature, I made serious errors because the original papers in Japanese were not authored by the inventor, but by surgeons. After seeing my paper, my former collaborator Professor Yoshi Honda, MD (1926–2003) of the Department of Physiology of Chiba University investigated this discovery and introduced me to the inventor, Takuo Aoyagi, Ph.D. Honda and I published corrections of this story in 1987 (16,17). I am indebted to Dr. Aoyagi and Akio Yamanishi (Minolta) for providing additional background described here related to the invention of pulse oximetry.

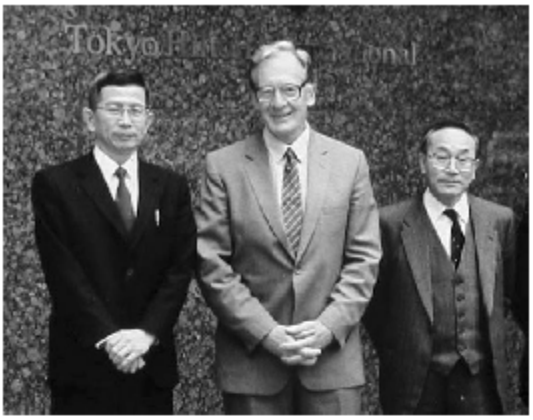

Figure 1. Takuo Aoyagi, John Severinghaus, and Yoshiyuki Honda, 1987.

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COVID 19 – REMINDERS AS WE RETURN TO WORK AND NORMAL OPERATIOINS

1. All University personnel must self-monitor and if there are any signs of COVID-19 infection (e.g. runny nose, sore throat, cough, shortness of breath, chills, muscle aches, headache, subjective fevers, diarrhea, nausea, abdominal pain, sudden loss of taste/smell), they must remain at home in self-quarantine and submit a request through the telehealth platform to be tested for COVID-19. If the employee is subsequently diagnosed as being COVID-19 positive, they should inform their supervisor immediately and quarantine for at least 14 days.
2. Mask Policy: Masks should be worn at all times on campus when social distancing is not possible [e.g. Shuttle buses (will not be allowed entry without a mask), elevators, high traffic areas such as hallways and stairwell etc.].
   A. Use a mask only once and dispose of after shift. If it becomes soiled during shift, please remove and get a new one.
3. Gloves have been placed in each office location. If you need more, please let Jenny Ann Smoak know.
4. Cleaning wipes have been placed in each office location for frequent cleaning of shared spaces (conference room, break room) and for faculty/staff offices. If you need more, please let Jenny Ann Smoak know.
5. Please wear a mask when entering other's offices and remain 6 ft if possible. Avoid touching things unnecessarily and perform hand hygiene often.

GRAND ROUNDS FOR THE MONTH OF JUNE

**Due to Covid 19 the scheduling of Grand Rounds and Lectures are very fluid/in flux, so please keep monitoring the weekly updates.

"Trauma"

June 2, 2020

Ashley Hink, MD

Dept. of Surgery

Medical University of South Carolina

"Peds Nora"

June 9, 2020

Michelle Rovner, MD

Dept. of Anesthesia & Perioperative Medicine

Medical University of South Carolina

"Airway Evaluation and Reviewing Different Disease Processes That Affect the Airway"

June 30, 2020

Maria Yared, MD

Dept. of Anesthesia & Perioperative Medicine

Medical University of South Carolina

MUSC
MEDICAL UNIVERSITY of SOUTH CAROLINA

Department of Anesthesia And Perioperative Medicine

Email: hiottg@musc.edu
Phone: 843-792-7503
Fax: 843-792-9314

Check out our website

Future Events/Lectures

Intern Lecture Series

No Scheduled Lectures at this time

CA 1 Lecture Series

Studying for ABA Basic Exams

CA 2/3 Lecture Series

Per Rotations

Grand Rounds

See Weekly Update

COVID-19 SYMPTOM ASSESSMENT DOT PHRASE IS NOW AVAILABLE...

.anescovid19preop

Please type into the note section under the assessment section and include in every Preop. New symptoms should trigger a discussion with the anesthesia and surgical team as it would take an **asymptomatic COVID negative** patient and turn them into a **SYMPTOMATIC covid negative** patient, which would require a **higher level PPE scenario** and a discussion re if the case should proceed or if the patient should be retested. The COVID response team can also be consulted for assistance, in addition to discussion with medi-

COVID 19 Periop Screen
Review of symptoms (now or any time in the last 14 days):
Anosmia (sudden loss of smell or taste): NO
Elevated temperature >99.0 F (37.2 C): NO
Fever >100.0 F (37.8C): NO
Subjective fever (felt like you had a fever, but didn't/couldn't measure one): NO
Chills: NO
Shaking chills/rigors: NO
Muscle aches (myalgias): NO
Runny nose (rhinorrhea):NO
Sore throat: NO
Cough (new onset or worsening of chronic cough): NO
Shortness of breath (dyspnea): YES
Nausea or vomiting: NO
Headache: NO
Abdominal pain: NO
Diarrhea (≥3 looser than normal stools/24hr): NO

PHYSICAL EXAM

Resident Graduation
Friday, June 26, 2020
Founders Hall

Resident Welcome Party
Saturday, August 1, 2020
Riverdogs game

Holiday Party
Friday, December 4, 2020
Carolina Yacht Club

Imagine 2020 Strategic Plan

We Would Love to Hear From You!

If you have ideas or would like to contribute to *Sleepy Times,* the deadline for the July edition will be June 22, 2020.