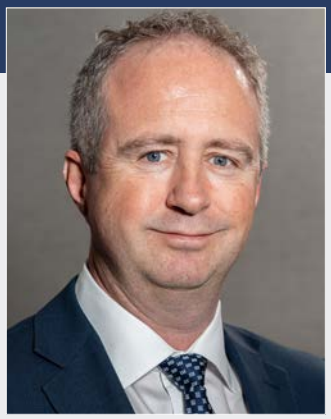
SCA NEWS

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

Volume 28, Number 12
December 2021

PRESIDENT'S MESSAGE



Andrew Shaw
MB, FCCM, FFICM, FRCA
President, Society of Cardiovascular Anesthesiologists

At this time of year our thoughts turn to the Holidays, to time spent with family and friends, and to reflections of the things that we are grateful for and have enjoyed throughout the previous twelve months. As President of the SCA I'm extremely grateful to be able to benefit from the education programs that our Society produces every year. In this holiday President's message then, I'd like to reflect on some of the activities that our Society's members have been involved in over the past twelve months.

In the December edition of the ASA Monitor, Dr. Chris Troianos and I describe the **joint effort between the ABA, the SCA, and many members of the cardiac anesthesia community to establish the process of Board Certification for Adult Cardiac Anesthesiology.** Although many cardiac anesthesiologists have been involved in this project, I would like to highlight the work of Dr. Tom McLoughlin and Dr. Chris Troianos, who together have led us through the inevitable organizational complexities and made this vision a reality. There is no doubt in my mind that future patients undergoing cardiac surgery will enjoy a higher standard of care as a result of the certification process. Examination committees are currently hard at work developing the curriculum and setting questions. The first certification examination will likely be given in 2023.

REFLECTIONS

At the recent meeting of the International Congress of Cardiovascular Anesthesiologists (ICCVA), held virtually and supported by our colleagues from EACTAIC in Rome, Italy, **the International Academy of Cardiac Anesthesiology was conceived. This international collaboration of cardiac anesthesia societies from around the world will promote the highest standards of education, clinical service delivery, quality improvement, and guideline and practice advisory development.** This vision was initially developed by Dr. Alex Mittnacht, Chair of our International Committee, myself, and Dr. Fabio Guarracino of EACTAIC. At the ICCVA meeting in November, Presidents, and other representatives of societies of cardiac anesthesia from all around the world came together for a two-hour virtual meeting to discuss the foundation, concepts, and goals/mission of this new Academy. We agreed to move forward collectively with its establishment and committed to an operational planning process. More details of this process will come in future months, and right now we are hard at work establishing the governance structure, financial basis, and mission statement for this new Academy. One of my Presidential priorities for our Society, for my tenure as your President, is international collaboration. As such, the foundation of the International Academy of Cardiac Anesthesiology represents a key milestone in the history of our Society. SCA will be a strong leader from the start of this new Academy, and our members will be well represented and deeply integrated into the work of this new organization.

Continued...

PRESIDENT'S MESSAGE

"We remain a strong organization because we are a community of committed, professional, and dedicated physician leaders."

As I write this in December 2021, **we are once again experiencing a surge in SARS-CoV2 cases.** My own hospital, those in my state, region, and in fact across the country are full of patients with SARS-CoV2. This is no time for editorial commentary about the politics of vaccination; rather it is a time for us all as physicians, cardiovascular anesthesiologists and SCA members to step up and support our colleagues in the intensive care units, our nursing staff colleagues, respiratory therapist colleagues, and everybody involved in the care of these acutely unwell patients. We must focus on measures that we know make a difference: wearing facemasks, physical separation, vaccination, and booster shots when indicated and available. This pandemic has stretched us all to our limits, and with each new surge we dig deeper into our own personal, professional, and emotional reserves. As I am sure all of you are, I am humbled by the resilience and the depth of emotional support that I see being offered by my colleagues every day to those folks we both work with and take care of. I am proud of our membership, I'm proud to be a physician, and I'm proud to deliver the best care I can to all patients, regardless of the choices they make regarding their healthcare.

In 2022 the **SCA will provide multiple educational opportunities for members, in the face of the ongoing COVID-19 pandemic.** We are making plans to deliver educational content both in person and via online technologies. Our Perioperative Ultrasound Course (POCUS, Feb 17), Echo Meeting (Feb 18-20), Cardiovascular Outcomes Research in Perioperative Medicine (COR-PM), Thoracic Anesthesia Symposium (both on May 13), and Annual Scientific Meeting (May 14-17) leadership teams are all working night and day to develop outstanding educational programming, in the face of extreme logistical headwinds. I am both proud of and grateful to the hundreds of physicians who work tirelessly on our behalf to plan, develop, and deliver all of our educational programming. I'm also extremely grateful to Dr. Jennifer Hargrave who leads our Online Education Sub-Committee. This committee will serve as an organizational unit for all online programming originating from all parts of our Society. It will be collectively organized and deployed to our membership through an online learning management system which has now been purchased and is being developed for full deployment. We hope this investment in our educational infrastructure will represent a real value-add for SCA members.

In closing, I am grateful to you, our membership community, for continuing to support our Society through these incredibly challenging times. We remain a strong organization because we are a community of committed, professional, and dedicated physician leaders. I have no doubt we will collectively come through this difficult time, and assemble as we used to once again, with a newly recharged emphasis on collective excellence, educational innovation, and the delivery of the highest quality clinical care for patients undergoing cardiac, thoracic, and vascular surgery. Please find some time during this holiday to leave the OR, the ICU, and the Inbox behind, and find some time to recharge, however you do that. For me it is steelhead season here in Ohio, which means mornings on the Chagrin River and relaxation time with family, loved ones, and friends. I hope this Holiday Season brings you peace and a chance to recharge. Our patients will surely be waiting for us when we return. Lastly, to those who are working clinically over the Holidays: a special thank-you. Your commitment to patient care is deeply appreciated and stands as a beacon representing everything we stand for as SCA members.

Happy Holidays all!

Andrew Shaw

PoCUS 2022

PoCUS is Back for 2022!

Join us for the return of the hands-on portion of the Perioperative Ultrasound Course at the SCA's Echo Week on February 17, 2022, in Atlanta, GA.

The SCA Perioperative Ultrasound Course offers training in utilizing basic clinical ultrasound to assist in clinical assessment and decision making and to guide percutaneous procedures. This reverse classroom–style program gives participants the opportunity to learn ultrasound skills through an online course, hands-on workshop, and online logbook.

The hands-on workshop provides in-depth and focused learning in an intimate environment with a faculty-to-participant ratio of about 1:4. You will gain practical knowledge from subject-matter experts on how to perform safe ultrasound procedures.

Attendees will gain practical knowledge from subject-matter experts on how to perform safe ultrasound procedures.

Please note: Eligibility to participate in the workshop first requires purchase of the online course. The online course can be **purchased online>>**

Register for 2022 PoCUS!

Click Here to view the preliminary agenda, registration rates and hotel information.

ECHO WEEK

ECHO 2022

Don't Forget to Register!

February is right around the corner which means it's time to register for Echo Week 2022. Join your fellow colleagues in Atlanta, GA from February 18 – 20, 2022.

The Echo Week three-day conference will feature:

- 3D Symposium
- Decision Making in Aortic and Tricuspid Valve Surgery – MOCA – Case Based
- Decision Making Mitral Valve Symposium
- MCS and Transplant
- Clinical Dilemmas
- State of the Art Future Directions

There will be in-person only, deep-dive sessions:

- 3D Image Acquisition
- Congenital Anatomy
- Post-Processing MPR/Strain
- Echo Anatomical Correlation for Surgical and Transcatheter Procedures

Register for the 2022 Echo Week!

Click Here to view the preliminary agenda, registration rates and hotel information.

Introducing the 15th Annual Arthur E. Weyman, MD, Lecturer

Dr. Madhav Swaminathan, MD FAHA FASE MBBS MMCI
Vice Chair, Faculty Development, Professor of Anesthesiology with tenure,
Duke University Hospital

The 2022 Weyman Lecture takes place Saturday, February 19, 2022. Make sure to **register** for Echo Week to hear Dr. Swaminathan speak.

COR-PM 2022

Register for the First Ever COR-PM Conference!

The Scientific Program Committee is thrilled to announce the first-ever Cardiovascular Outcomes Research in Perioperative Medicine (COR-PM) conference to be held in person and online on Friday, May 13th, 2022, in conjunction with the following SCA 44th Annual Meeting and Workshops in beautiful Palm Springs, California.

The Program will feature:

- Advance your understanding of high-quality clinical outcomes research within the T2-T4 translational spectrum.
- Provide mentorship capacity for early and mid-career participants by providing a small-sized conference that permits "face time" with recognized leaders in the field, including Drs. PJ Devereaux, Dan Sessler, Jessica Spence, Monica Vavilala, Eric Sun, and many more.
- Create a personal, inclusive, and welcoming conference.

Be a part of the First COR-PM Conference

Click Here to view the preliminary agenda, registration rates and hotel information.

THORACIC ANESTHESIA SYMPOSIUM

TAS 2022

Don't Miss Out — Early Bird Discount Available NOW through February 18, 2022.

EARLY BIRD DISCOUNT

Your Registration is Awaiting!

The Thoracic Anesthesia Symposium (TAS) Planning Committee invites you to join the world of non-cardiac anesthesiologists from around the world for the 2022 TAS meeting on May 13, 2022, in Palm Springs, California.

Look forward to:

- A focus on dramas, traumas, experts, and controversies, along with everyday challenges in the chest.
- Thought leaders provide a deep-dive exploration of new topics in thoracic surgery and anesthetic challenges.
- Hands-on workshop format! Focus on your clinical interests and explore what is new with an interactive experience with the authorities in the field.

At the SCA Thoracic Anesthesia Symposium you can:

- Choose 3 in-person workshops and register for an optional live PBLD for a conference experience tailored to YOUR educational needs.
- Network with 200 other professionals in anesthesiology to help you gain insight into your practice and career.
- Connect with our exhibitors to learn about new products and programs.

Click Here to view the preliminary agenda, registration rates and hotel information.

SCA ANNUAL MEETING

SCA 2022

SCA 2022

Join Us and Celebrate Together!

Early Bird Discount Available NOW Through February 18, 2022 — Registration is Open!

Join your fellow members in Palm Springs, CA for the latest cardiothoracic anesthesia information through fantastic plenary sessions, controversial panel discussions, pro-con debates, hands-on workshops, mentoring sessions, and problem-based learning sessions.

Look forward to:

- Amazing content delivered by experts in cardiothoracic anesthesiology, interventional cardiology and cardiothoracic surgery.
- Experts will provide didactics, small group breakout teaching, and high-yield discussions.
- Problem based learning discussions, scientific abstracts, and workshops are planned to optimize attendee learning and connection on critical cardiothoracic anesthesiology topics.
- Attendee networking, idea-sharing, and exhibits.

This year, in-person you can:

- Attend live discussion sessions to help you discover up to date practice pathways and innovations in the field.
- Register for Workshops and PBLDs tailored for YOUR educational needs.
- Network with 1,200 other professionals in anesthesiology to help you gain insight into your practice and career.
- Connect with industry and exhibiting companies to learn about new products and programs.

Click Here **to view the preliminary agenda, registration rates and hotel information.**

Introducing the 2022 Annual Meeting Earl Wynands Lecturer

Dr. Eric Jacobsohn, MBChB, MPHE, FRCPC

Professor and Chair with tenure, Department of Anesthesiology, University of Manitoba
Professor, Department of Internal Medicine; Medical Director, Winnipeg Regional Health Authority Anesthesiology Program.

The 2022 Earl Wynands Lecture takes place Sunday, May 15, 2022. Make sure to **register** for the Annual Meeting to hear Dr. Eric Jacobsohn speak.

Research Grant Applications Closing January 20, 2022

SCA encourages all eligible members to apply for 2022 Research Grants.

The following SCA/IARS Research Grants are available through the 2022 Grant Application.

SCA Members are eligible to apply for 1 of 3 types of grants offered in 2022:

- **SCA/IARS Starter Grant** — *up to $25,000 a year for 2 years*
- **SCA/IARS Mid-Career Grant** — *up to $50,000 a year for 2 years*
- **Diversity & Inclusion Grant** — *up to $25,000 a year for 2 years*

Award recipients will be announced and presented during the SCA 2022 Annual Meeting & Workshops in Palm Springs, California.

The grant period of 24 months can begin any time from July 1 to December 31 of the year granted.

Applications will close on **January 20, 2022**. Click Here Research Grants for more information about these funding opportunities.

Click Here to review the eligibility, application requirements, and to learn more about past winners. Make sure to submit your application by 11:59 pm CST on Monday, January 20, 2022.

The Kaplan Leadership Development Award is NOW Accepting Applications!

The 2022 Kaplan Leadership Development Award application submission open December 1, 2021. The award is designed to assist cardiothoracic and vascular anesthesiologists in their career by granting funding to further their leadership development through coursework and leadership-specific studies.

The Kaplan Leadership Award will be adjusted accordingly to offer an aggregate of $5,000 to either one recipient or divided among two

- **$5,000/$2,500 from the SCA Endowment, with a $5,000/$2,500 match from the applicant's institution to fund a leadership education strategy.**

The deadline to submit your application is January 29, 2022.

Click Here Kaplan Leadership Development Award for more information on this award and how to apply.

Questions about the grant and grant application should be emailed to operations@scahq.org, or via telephone at 855.658.2828.

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

SCA NEWS

Become Involved Today

Call for Volunteers Opening Soon!

Are you looking to get even more out of your SCA membership? Consider applying for an SCA volunteer position on a committee, sub-committee, or working group!

More than 650 SCA members are engaged in the Society's work by serving on nearly 50 different groups (i.e., Committees, Sub-Committees, Working Groups). These groups are formed to achieve a specific goal designed to enhance the membership experience for Society members.

Each group takes a different structure, form, and function:

Committees Long-standing groups within the Society that focus on more extensive strategic measures.

Sub-Committees Support the work of Committees and have a specific focus with specific goals.

Working Groups Groups brought together by common knowledge to complete detailed work, as outlined by their parent Committee or Sub-Committee.

Committee Member Expectations:

- SCA membership must be in good standing.
- Attend at least 50% of meetings (including conference calls and in person).
- Review meeting materials in advance and respond promptly to communications.
- Demonstrate enthusiasm: act ethically, conscientiously, and with respect. for other group members, SCA members, and the SCA management team.
- Be able to work effectively both independently and with a team.

Applications for the 2022 Call for Volunteers opens in January 2022.

You Make a Difference by Supporting the SCA Endowment

December 31st is approaching—donate to SCA to take advantage of tax deductions!

By donating to the SCA Endowment, you help SCA achieve its mission and assist cardiovascular anesthesiologists in furthering their education, research, and professional development.

Making an online donation is quick, easy, and secure. Access the SCA Endowment Fund donation page by visiting **SCA Endowment.**

For more details on the Endowment, please email donation@scahq.org.

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

SCA NEWS

Voting Opening Soon

SCA 2022 Nominating Slate

The SCA Nominating Committee, chaired by Immediate Past President, Dr. Stan Shernan, MD FAHA FASE, is pleased to endorse the following candidates for the 2022 election cycle. Information about each candidate will be available in the February newsletter and through the online election system.

Two positions are available for Director-at-Large, among the following nominees:

- Jacob T. Gutsche, MD, University of Pennsylvania, Perelman School of Medicine
- David McIlroy, MD, MBBS, FANZCA, MClinEpi, Vanderbilt University Medical Center
- Danny Muehlschlegel, MD, MMSc, MBA, FAHA, FASA, Brigham and Women's Hospital, Harvard Medical School
- Daryl Oakes, MD, Stanford University
- Nanette M. Schwann, MD, FAHA, Lehigh Valley Health Network
- George Semien, MD, MPH, MSc, FASE, FASA, University of Mississippi Medical Center
- Annemarie Thompson, MD, Duke University

Two positions are available for the Early Career Board Director, among the following nominees:

- Jessica Brodt, MBBS, FASA, Stanford University
- Theodore Cios, MD, MPH, FASA, FASE, Hershey Medical Center
- Adam A. Dalia, MD, MBA, FASE, Massachusetts General Hospital
- Sharon McCartney, MD, FASE, Duke University
- Nadia B. Hensley, MD, Johns Hopkins School of Medicine
- Stephanie Ibekwe, MD, MPH, Baylor College of Medicine
- Sergey Karamnov, MD, Brigham and Women's Hospital
- Michael A. Mazzeffi, MD, MPH, MSc, FASA, George Washington University School of Medicine
- Samhati Mondal, MBBS, MD, University of Maryland School of Medicine
- Peter Neuburger, MD, FASE, NYU Grossman School of Medicine
- Richard Sheu, MD, FASE, University of Washington
- Bantayehu Sileshi, MD, Vanderbilt University Medical Center
- Emily G. Teeter, MD, FASE, University of North Carolina, Chapel Hill
- * *Adam J. Milam, MD. PhD, Mayo Clinic*
- * *Toby Beth Steinberg, MD, Medical University of South Carolina*

* *Not endorsed by the Board of Directors*

One position is available for the CME Committee Member, among the following nominees:

- Andaleeb Ahmed, MD, MPH, Lahey Hospital and Medical Center
- Jenny Kwak, MD, FASA, FASE, Jenny Kwak, MD, FASA, FASE
- Mathew Varghese Patteril, MD, FRCA, AFFICM, University Hospitals of Coventry and Warwickshire
- Ali Salehi, MD, FASA, Ronald Regan UCLA Medical Center

The 2022 online election for SCA leadership is scheduled to open on January 27, 2022.

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

Connect with SCA DocMatter!

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

Doc+Matter

THE SCA DOCMATTER COMMUNITY

The SCA is very excited to present our newest member benefit — the SCA DocMatter Community! The goal of the SCA Community is to recreate the environment of learning and networking that happens at in-person meetings and educational events, making this the ideal way to stay in touch with your peers and keep current on new procedures, technologies, and advances in the fields of cardiovascular and thoracic anesthesiology. You will always have a front-row seat for the Q&A.

The DocMatter Team will moderate and organize posts to make sure the content is clinically relevant to SCA Members. Each SCA Member will also be paired 1:1 with a member of the DocMatter Clinical Support Team to make sure that this new resource fits most conveniently into your current workflow, and they will do everything they can to make sure you can collaborate with fellow SCA members for a "virtual curbside consult" — anytime, anywhere. Please see the below graphic for examples of how the on-demand support available to you.

Please look out for messages from the DocMatter Team to get you started. We are looking forward to seeing active participation from SCA leadership and thought leaders and hope to hear what you think about this new SCA Member resource!

Private, Supported Collaboration and Networking with Fellow SCA Members

Real People Help You:

- **Make Connections** We'll build your profile and update your preferences *on your behalf*
- **Get Your Questions Answered** We identify *and connect you with the experts* on topics of interest *to you*
- **Discover the Latest Research** We add referenced literature to posts and help members share published (and working) content for feedback and further discourse
- **Draft and Post Discussion Prompts and Responses** to teach and learn from your peers (*simply send or dictate notes*)
- **Save Time** by moderating Discussions, avoiding off-topic and duplicate conversations, and collecting and organizing past Discussions for quick and easy reference

Join Your Community at docmatter.com/SCAhq

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

2023 SF Match Fellowship Agreements are NOW Open!

In-order to provide more consistency and predictability to the ACTA fellowship application process, the ACTA programs participate in a common application and match process provided by SF Match for recruitment.

Timetable: 2022 Adult Cardiothoracic Anesthesiology Fellowship Match for 2023 Positions

Applicant Registration Began	Central Application Service Target/Deadline date	Rank List Submission and SCA Exception Agreement Deadline	Results Sent to Programs /Applicants and Medical Schools	Post-match Vacancies Posted	Training Position Starts
November 8, 2021	March 2, 2022	June 2, 2022	June 9, 2022	June 10, 2022	July, 2023

Submit Your SF Match Agreement

Applicants and programs participate by registering with SF Match and applicants applying to the programs of their choice. Both programs and applicants submit a rank list based on their preferences. Notably, only programs where an applicant has interviewed can be ranked in the match.

Critical to the match process, programs and applicants can make an Exception Agreement prior to submitting their rank list to SF Match. Exception Agreements allow an applicant and program to agree to match each other prior to submitting their respective rank lists. Importantly, all ACTA positions must be included in the match, including all Exception Agreement positions.

Exceptions to the standard match process have been agreed upon by the ACTA Fellowship Program Directors Council in the following situations:

1. Applicants who are in active military service at the time of application.
2. Internal candidates, i.e. applicants who are currently in the anesthesiology residency program at the same institution as the ACTA fellowship.
3. Applicants who are making a commitment to come to the institution of the ACTA fellowship for more than one year.
4. Applicants who are enrolled in an anesthesiology residency outside of the USA at the time of application.
5. Applicants who reside outside the USA at the time of application or who are not eligible for ABA certification due to non-US training.
6. Applicants whose spouse or partner is applying for a GME-approved post graduate training program in a medical specialty in the same region as the ACTA fellowship.

Please Note: *Eligible applicants and programs who wish to take advantage of an exception rule are still required to participate in the match ranking process and must complete an exception agreement found on the SCA website via the link below. Any match irregularities will be referred to the ACTA Fellowship Program Directors Council of the SCA.*

Program directors complete the first part of the match exception process. **Program directors — click here to begin.** You will need to log in with your SCA username and password. Once the program director completes this portion of the process, the applicant will receive an email with a link to the form they must complete.

Any match irregularities will be referred to the ACTA Fellowship Program Directors Council of SCA.

SCA MEMBER CORNER

AWEsome Woman Interview

Daryl A. Oakes, MD

Stanford University School of Medicine

Dr. Oakes received her medical degree from Harvard Medical School, followed by internship and residency in anesthesiology at the Brigham and Women's Hospital. She completed clinical fellowship in adult cardiac anesthesiology at Stanford and joined our faculty in 2006. Dr. Oakes has received teaching awards and distinguished herself as an educator at Stanford. She is currently the program director of the adult cardiothoracic anesthesia fellowship in the Department of Anesthesia and is well-versed in the ACGME accreditation process. She is a national expert on the perioperative use of transesophageal echocardiography.

During her time on the Stanford faculty, Dr. Oakes has developed several innovative programs, including developing curricula to train residents in basic perioperative transesophageal echocardiography. This echocardiography training experience has been a model for anesthesia programs nationally. She is currently the Co-Vice Chief of Education in the Stanford's Division of Cardiac Anesthesia.

1. What led you to become a Cardiovascular/Thoracic Anesthesiologist?
I was fascinated by cardiopulmonary physiology as a medical student and when I rotated through the cardiac anesthesiology OR during an anesthesiology rotation and helped with my first resuscitation, I was hooked.

2. How did you hear about the SCA?
I was introduced to the SCA by my colleagues at Stanford, including Dr. Christina Mora, who was the 1st female President of the SCA. My early involvement began with an opportunity to prepare and give a lecture in an SCA session with a senior advising colleague. I had the fortune to be paired with Dr. Colleen Koch, and it was a fantastic experience. The mentorship and connections I have developed in the SCA have been hugely valuable to my career.

3. What roles have you held for the society?
I have served on the SCA Scientific Program Committee from 2011-2015 and the SCA ACTA Fellowship Program Director's Consortium from 2017-present. In the Consortium, I chair a task force on Diversity focused on developing strategies to recruit a more diverse pool of trainees into cardiothoracic anesthesiology.

I recently helped co-found and now serve as Chair for the Women In Cardiothoracic Anesthesiology (WICTA), SCA Special Interest Group. WICTA now has over 340 members and supports professional development and mentorship to help build a stronger, more diverse professional community here at the SCA.

In addition to regular networking events (WICTA Happy Hours), we run an annual mentorship program series, the Professional Development, and Mentorship Program (PDMP), which provides structure mentoring on topics including professional speaking and research project development. We also offer honorary awards, which provide our member's recognition and professional development

opportunities. Past awards have included professional coaching from Dr. Karen Souter and leadership training from Dr. Sasha Shillcutt's BraveEnough MasterClass.

We have launched the WICTA Speaker Database to help connect meeting planners with a broader, more diverse panel of potential professional speakers.

4. What is one of your greatest achievements as a cardiovascular/thoracic anesthesiologist?

One of my most outstanding achievements is training and mentoring the next generation of cardiothoracic anesthesiologists both in my role as an ACTA Fellowship Program Director and in my role as Chair of WICTA. I want to make this fantastic and exciting field accessible to a more diverse pool of talented clinicians and scientists.

5. Do you have any advice for fellows and residents?

I would encourage all trainees to seek out and utilize a broad array of mentorship opportunities at your institution and nationally through groups like the SCA and WICTA. Remember that not all mentorship connections lead to immediate results, but the relationships you develop can be precious in the long term. Although it may sometimes feel awkward to "ask for help," people, even those prominent in our field, really enjoy serving as a resource.

Having discrete requests are often a great entry. For example, emailing a committee member, you are interested in and asking how you can get more involved in the committee or if you can help on a specific project.

6. Have you experienced any difficulties as a woman in the field?

Managing a family and a career is challenging and requires constant rebalancing and configuring. I had periods of my career where my family's needs have needed me to work part-time. Doing so allowed me to spend valuable time with my family at crucial moments of my kids' lives.

Unfortunately, however, taking these decreases in my FTE for portions of my career did have a negative impact on the trajectory of my professional advancement and the professional opportunities available to me. This experience has made me passionate about creating opportunities for more flexible work schedules and creating alternative models for a career trajectory that are more appropriate to individuals with family and personal needs.

7. Do you have any advice for other women in the field?

Being a woman in medicine can be challenging at times. While we all know how to work hard, and all of us do, it is also essential to learn to be strategic. This means making sure that your significant activities provide you with opportunities for professional visibility and advancement and also making sure you "beat your own drum" and take credit for the not-so-visible but essential work that you also do.

In addition, it is vital to develop a strong support network early. This can be peers and colleagues and mentors from various areas in your career. These people will be an invaluable resource when you run into challenges during your career. Remember, you are not the only one struggling at times, so do not suffer alone! Your colleagues often have faced the same challenges and may have great advice for how to navigate these moments, and, if not, at least can be a source of emotional support to you.

8. How do you balance work and personal life?
There are only so many hours in the day, so do not be afraid to "out-source" anything that is not critical you do yourself. Also, if you will be all you need to be for all the people who need you in your life, you must "put your oxygen mask on first."

Although you deserve to do self-care for your sake, if you need additional encouragement, remember, it will make you better and more available to those who need you most if you FIRST take care of yourself!

9. What is something you enjoy doing outside of work?
I love hiking and enjoy exploring the many beautiful hikes and outdoor spaces in the California Bay Area.

10. Would you change anything about the path you took to get to where you are now?
I would have developed more connections with professional peers and mentors at other institutions earlier in my career. Finding opportunities to join national committees or organizations through the SCA and other societies (or WICTA!) are an excellent way to make these connections.

11. What was the best piece of advice you received?
Don't underestimate yourself. You do not need permission to be a leader; you are ready now!

MEMBER CORNER

Time to Renew?

SCA would like to take this opportunity to thank you for your continued support during 2021. Your involvement is important and very much appreciated. We hope that you would take the time to renew your membership and remain part of our organization. It couldn't be easier — just **click here** to pay your dues online.

If you have any questions regarding your membership dues, please contact Karen Potempa at **karen@veritasamc.com**.

Fellow Membership Update!

Congratulations to all who have recently completed their fellowship! When renewing your SCA membership, please be sure to renew at the active or associate rate. Should you need assistance when doing so, please contact Karen Potempa at **karen@veritasamc.com**.

Member Benefit: JCVA Subscription at Discounted Rates

All SCA members are eligible to subscribe to the Journal of Cardiothoracic and Vascular Anesthesia (Red Journal) at discounted rates!

JCVA is primarily aimed at anesthesiologists who deal with patients undergoing cardiac, thoracic, or vascular surgical procedures. The Red Journal features a multidisciplinary approach, publishes clinically relevant material, and encourages innovative submissions from all continents.

Journal Benefits:

- Access to all multimedia content (e.g., podcasts, videos, slides).
- Fully optimized mobile browsing experience on your smartphone or tablet.

Visit **JCVA Journal** for more details and to take advantage of special SCA member rates!

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

THORACIC CORNER

Initial Postoperative Hemoglobin Values are Independently Associated With One-Year Mortality in Patients Undergoing Double-Lung Transplantation Requiring Intraoperative Transfusion

Menger J, Koch S, Mouhieddine M, et al. Journal of Cardiothoracic and Vascular *Anesthesia* 35 (2021) 2961-2968

Reviewers:

Ashley Virginia Fritz, DO
Archer Kilbourne Martin, MD
Division of Cardiovascular and Thoracic Anesthesiology
Mayo Clinic College of Medicine, Jacksonville, Florida

Background

Anemia in cardiac surgical patients has been associated with increased in-hospital death, stroke, and acute kidney injury.[1] Anemia after transplantation can be secondary to intraoperative blood loss, inappropriately low erythropoietin levels, renal impairment, bone marrow suppression, and frequent laboratory draws.[2] Recent literature supports the hypothesis that preoperative anemia in patients undergoing lung transplantation is independently associated with longer hospital length of stay and increased risk postsurgical bleeding necessitating reoperation.[1] The authors from the Medical University of Vienna set out to evaluate the association of postoperative anemia and mortality in bilateral lung transplant patients who underwent intraoperative transfusion of packed red cells.[3]

Methods

The authors describe a single center, retrospective, cohort study conducted between 2009 and 2015 assessing one-year mortality in adult double-lung transplant recipients. Five hundred fifty-four patients were included in the study. Patients excluded from this study included those with combined transplant procedures, single lung transplant, patients who did not receive intraoperative transfusion of red cells, and those who required re-do thoracotomy secondary to bleeding. All patients underwent sequential, bilateral double-lung transplant. Central venoarterial ECMO was instituted per local protocols, resulting in approximately 76% utilization rate. Volume resuscitation with colloids (Human serum albumin, 6% hydroxyethyl starch, or fresh frozen plasma) was preferred over crystalloid resuscitation. Packed red blood cell (PRBC) transfusion was directed by the anesthesiologist with recommendations to avoid hemoglobin levels less than 8g/dL. The primary outcome was postoperative mortality during the first year following transplantation and secondary outcomes included acute kidney injury during first seven post-operative days, time to extubation, and primary graft failure.

Results

During the study period 554 patients received intraoperative blood transfusion. The utilization rate of intraoperative venoarterial ECMO (VA ECMO) was 76%. The authors reported lower postoperative hemoglobin levels (< 11.3g/dL) were associated with higher transfusion of fresh frozen plasma and VA ECMO use. The authors theorized that higher postoperative hemoglobin levels could be secondary to higher initial hemoglobin levels, less dilution, blood-sparing technique utilization, or a higher rate of intraoperative packed red cell transfusion.

The mortality rate over all was 17% one-year post-transplantation, as 93 patients had expired. Mortality was 14% in those patients with a postoperative hemoglobin of >11.3 g/dl and 24% in those patients with a hemoglobin <11.3 g/dl (p=0.004). Anemic patients demonstrated increased incidence of severe primary graft dysfunction over non-anemic patients, however both demonstrated similar rates of acute kidney injury. Interestingly, the gap in survival widened beyond 50 days after transplantation. The authors theorized that higher initial postoperative hemoglobin contributes to better graft function and less systemic hypoxemia.

Discussion

This paper highlights the association of higher postoperative hemoglobin with better one-year survival rates in bilateral lung transplantation. In cardiac transplantation patients, postoperative anemia has been shown to be more common than preoperative anemia.[2] In addition, anemic patients demonstrated worse survival than non-anemic patients at 3 years with a 100% survival rate for those non-anemic patients and 85% for those patients who were anemic.[4,5] As the number of lung transplant recipients continues to increase, it is imperative to further identify areas for optimization in perioperative management and patient outcomes. This manuscript suggests further assessments are needed to identify the optimum transfusion trigger or "lowest safe hemoglobin level" in patients undergoing lung transplantation to improve outcomes.[3]

References

1. Hernandez-Morgan M, Neelankavil J, Grogan T, Hong B, Wingert T, Methangkool E. Preoperative Anemia as a Risk Factor for Postoperative Outcomes in Patients Undergoing Lung Transplantation. *J Cardiothor Vasc An.* 2021;35(8):2311-2318.
2. Taegtmeyer AB, Rogers P, Breen JB, Barton PJ, Banner NR, Yacoub MH. The effects of Pre- and Post-transplant Anemia on 1-year Survival After Cardiac Transplantation. *J Heart Lung Transplant.* 2008;27(4):394-399.
3. Menger J, Koch S, Mouhieddine M, et al. Initial Postoperative Hemoglobin Values are Independently Associated with One-Year Mortality in Patients Undergoing Double-Lung Transplantation Requiring Intraoperative Transfusion. *J Cardiothor Vasc An.* 2021;35(10):2961-2968.
4. Muller HM, Aigner R, Horina JH, et al. Mild Chronic Anemia Following Heart Transplantation: A Syndrome with Prognostic Relevance? *Transpl Int.* 1998;11(6):413-418.
5. Muller HM, Horina JH, Kniepeiss D, et al. Characteristics and Clinical Relevance of Chronic Anemia in Adult Heart Transplant Recipients. *Clin Transplant.* 2001;15(5):343-348.

LITERATURE REVIEWS

Echocardiographic Correlates of In-Hospital Death in Patients with Acute COVID-19 Infection: The World Alliance Societies of Echocardiography (WASE-COVID) Study

Karagodin I, Carvalho Singulane C, Woodward GM, et al. *J Am Soc Echocardiogr.* 2021;34(8):819-830.

Reviewers:

Maryte Gylys, MD
Department of Anesthesiology & Perioperative Medicine
University of California, Los Angeles

Reed Harvey, MD
Assistant Clinical Professor
Department of Anesthesiology & Perioperative Medicine
University of California, Los Angeles

Background

While COVID-19 is known to directly affect the respiratory system, growing evidence has accumulated regarding extra-pulmonary manifestations of the virus. Specifically, COVID-related cardiovascular disease has been recognized as an important factor in disease progression and patient outcomes.[1,2] Interestingly, patterns of COVID-19, including case number, deaths, and mortality rate vary substantially across different global geographic regions.

To answer uncertainties regarding the cardiovascular effects of COVID-19 and characterize geographic patterns of the disease, the World Alliance Societies of Echocardiography (WASE) designed this study, with the goals being to characterize the clinical and echocardiographic phenotypes of acute cardiac disease in Covid-19 patients, compare phenotypic differences among geographic regions, and identify parameters associated with in-hospital mortality.

Methods

This retrospective study included hospitalized, adult patients from four world regions (Asia, Europe, United States, Latin America) diagnosed with COVID-19 from January 2020 to September 2020. Patients were eligible for inclusion if they had a transthoracic echocardiogram (TTE) including the apical 4-chamber view performed during their initial COVID-19-related hospitalization. Echocardiograms were ordered and acquired based on local clinical practice.

TTE images were electronically imported for central analysis by the principal investigators. Additional data collected included demographics, medical history, hospital vital signs, and the biomarkers troponin, LDH, BNP, D-dimer and CRP if collected within 72 hours of TTE image acquisition.

Analysis of the TTE images was performed by an artificial intelligence (AI) algorithm and by human interpreters. The AI algorithm created by machine learning was used to generate left ventricle (LV) parameters including ejection fraction (LVEF), end systolic and diastolic volume (LVESV, LVEDV), and longitudinal strain (LVLS). These measurements were manually repeated by an accredited echocardiographer. Right Ventricle (RV) analysis was performed with a semi-automated package to determine global longitudinal strain (RVLS), free-wall strain

(RVFWS), and basal diameter (RVBD).

The primary outcome was in-hospital death. Multivariate regression analysis was performed to identify associations between patient clinical factors, TTE findings, and patient outcomes.

Results

The study enrolled 870 patients in 13 medical centers located in nine different countries. The various study centers had different TTE acquisition protocols, so the studies varied in completeness. There was a temporal trend in case enrollment by geographic region, reflecting the expansion of the pandemic from Asia to Europe, followed by the US and Latin America.

Overall, LVEF was normal (>50%) in 83% of patients, mildly reduced in 11%, moderately reduced in 5%, and severely reduced in 3% of patients. In evaluating measures of LV and RV strain, severely abnormal LVLS (>-15%) was present in 22% of patients and severely abnormal RVFWS (>-20%) was present in 29% of patients. Not surprisingly, patients admitted to the ICU at the time of echo had significantly worse LVLS and RVFWS.

The authors found that patients in Asia had fewer comorbidities, better biomarker profile, and required less hemodynamic and ventilatory support. Regional differences in LVEF, LVLS, RVFWS, and RVBD were also observed, with the best values found in Asia, followed by Europe, Latin America, and lastly the United States.

Overall, in-hospital mortality was 21.8%. Multivariate analysis found that age, LDH, prior lung disease, and reductions in LVLS and RVFWS to be independently associated with in-hospital death (the primary outcome). Receiver operator characteristic (ROC) curves were used to identify optimal cutoff values: 65 years of age, 389 U/L LDH, -16.7% LVLS, and -20.2% for RVFWS.

Discussion

This study had a broad set of goals, including characterization of the echocardiographic phenotype of COVID-19 and identification of prognostic factors and geographic variability. While not surprising, this study demonstrated that patients with evidence of cardiac dysfunction injury, identified by echocardiographic or biomarker profile, have worse clinical outcomes. The more pressing issue that this study attempts to address is which specific echocardiographic measurements or clinical biomarkers carry the best prognostic value in patients with COVID-19.

In contrast to multiple prior investigations from Wuhan[3] and New York,[1] the WASE study did not identify troponin elevation as a factor significantly associated with mortality. The authors attempt to offer a possible explanation of selection bias, as troponin was only measured in 35% of those study participants. A more complex explanation is that troponin elevation represents a state of severe illness, or sepsis causing increased cell permeability, without signifying direct myocardial injury.

The WASE authors suggest that strain variables (LVLS and RVFWS) are superior predictors of mortality in patients with COVID, compared to the more conventional metric of LVEF. This assertion is corroborated by researchers from Israel who found that RV dysfunction was the most common echo finding in

patients with COVID-19 and the finding most associated with clinical deterioration.[4] Similarly, another group from China also concluded that RVLS is a powerful predictor of mortality.[5]

There was significant diversity in cardiac phenotype and echocardiographic utilization noted across the four geographic regions. The authors hypothesize that this geographic variability may be explained by regional differences in patient comorbidities, or by selection bias, with echos more selectively being performed on the most critically ill patients as the pandemic crept across the globe.

It should be noted that this was the first large international study of its kind. Further, one of the most unique aspects of this study was the use of AI in echo analysis. This is the first large-scale study to utilize this technology, and it may pave the road for increased use in the future.

The authors acknowledge several limitations of the study. The number of patients included in the study was relatively small compared to the global scale of the pandemic. TTE images were less than optimal, as there was no standardized protocol and examiner safety was of grave concern early in the pandemic. Notably, the patient cohort in this study had a clinical indication for TTE and so are more likely to have cardiac involvement than the general population of COVID-19 patients. The authors acknowledge that although LVLS and RVFWS were independently associated with mortality, their sensitivity is limited, and so should be considered in context of clinical factors such as age and LDH.

In sum, the WASE study finds that LVLS, RVFWS, age, LDH, and prior lung disease are associated with in-hospital mortality while highlighting regional differences in cardiac phenotype and echo utilization.

References

1. Lala A, Johnson KW, Januzzi JL, et al. Prevalence and Impact of Myocardial Injury in Patients Hospitalized With COVID-19 Infection. *J Am Coll Cardiol.* 2020;76(5):533-546. doi:10.1016/j.jacc.2020.06.007.
2. Uriel N, Sayer G, Clerkin KJ. Myocardial Injury in COVID-19 Patients: The Beginning or the End?. *J Am Coll Cardiol.* 2020;76(5): 547-549. doi:10.1016/j. jacc.2020.06.045
3. Shi S, Qin M, Cai Y, et al. Characteristics and Clinical Significance of Myocardial Injury in Patients with Severe Coronavirus Disease 2019. *Eur Heart J.* 2020;41(22):2070-2079. doi:10.1093/eurheartj/ehaa408
4. Szekely Y, Lichter Y, Taieb P, et al. Spectrum of Cardiac Manifestations in COVID-19: A Systematic Echocardiographic Study. *Circulation.* 2020;142(4):342-353. doi:10.1161/CIRCULATIONAHA.120.047971
5. Li Y, Li H, Zhu S, et al. Prognostic Value of Right Ventricular Longitudinal Strain in Patients With COVID-19. *JACC Cardiovasc Imaging.* 2020;13(11): 2287-2299. doi:10.1016/j.jcmg.2020.04.014

Association of Frailty with Days Alive at Home After Cardiac Surgery: A Population-based Cohort Study

Daniel I. McIsaac, Alexandra Fottinger, Ewa Suchaand Bernard McDonald
British Journal of Anaesthesia, 126 (6): 1103e1110 (2021)
doi: 10.1016/j.bja.2021.02.011

Reviewers:

Vivek Gulati, MD
University of California Irvine Medical Center

Antonio Hernandez Conte, MD MBA FASA
Kaiser Permanente Los Angeles Medical Center

Background

Frailty is a geriatric syndrome with a wide range of contributing factors and comorbidities that has been found to have significant prognostic value within cardiac and non-cardiac surgery. Within cardiac surgery, we know that a patient being deemed "frail" is a major independent risk factor with a 1.5-fold increase in major adverse cardiac events and overall increased post-operative mortality. However, beyond mortality, the influence of frailty on post-operative outcomes has not yet been well established. Important post-operative outcomes including length of stay, readmission, and non-home discharge are essential in understanding the post-operative course in this growing, vulnerable patient population that is not well encapsulated by mortality alone. Additionally, these secondary outcomes can help us better understand the non-operative sequelae of cardiac surgery and the post-operative hospital course.

By better understanding frailty and how to risk-stratify patients based on a wider breadth of measures of frailty, we can have a more informed preoperative discussion about the risks and benefits of cardiac surgery. We often frame that discussion around mortality, which is an essential part of the preoperative discussion, but older patients also greatly value their independence and the ability to return to their previous functional state. Due to this, it is pertinent to discuss aspects of their care that carry inherit risk of functional decline. For the elderly, the mere fact they are hospitalized is one of those risk factors. In fact, functional decline is one of the main complications as a result of hospitalization, which has been found to correlate with bedrest orders and low levels of activity that may not always be medically indicated. In order to better study outcomes in this population, it is important to study outcomes that may be of importance in predicting functional decline post-operatively such as 'days alive at home' (DAH), which would allow for a greater understanding of how frailty impacts not only mortality but also post-operative independence in older patients.

Study Design

This study utilized a population-based cohort design pulling data from the Ontario healthcare system. The cohort studied included all Ontario residents >65 years old having one of the five most common cardiac surgical procedures: isolated coronary artery bypass graft (CABG), isolated aortic valve repair/replacement, combined CABG and aortic valve repair/replacement, combined CABG and mitral valve repair/replacement, or multivalve surgery. The exposure within this study was frailty, which was defined using the preoperative frailty index (pFI). The pFI is a

multidimensional frailty index that proportionally utilizes 30 accumulated deficits (symptoms, signs, functional impairments, and laboratory abnormalities) to yield a score of 0-1, with a cutoff value of >0.21 to define frailty. The primary outcome was days alive at home in the 30 days after surgery (DAH30) with a secondary outcome of days alive at home in the 365 days after surgery (DAH365).

Results

The study evaluated 61,389 older individuals having their first cardiac surgery with frailty being the key exposure stratified based upon pFI. For the cohort, mean pFI was 0.23 with the frailty cutoff being >0.21. The primary outcome, DAH30, showed a significant difference between the dichotomized frail (pFI>0.21) and not frail (pFI<0.21) groups with DAH30 of 16.0 and 21.1 days respectively. After being adjusted for covariance (age, sex, urgency, and procedure type) the frail subgroup showed a 20% decrease in DAH30. When evaluated on a continuum, frailty and DAH30 continued to yield a direct correlation with each 10% increase in pFI being associated with a 21% decrease in DAH30 (CI 19-22%). This direct correlation held true for the secondary outcome of DAH365 as well, with each 10% increase in pFI yielding an 8% decrease in DAH365. On further analysis of what components of DAH scoring led to these differences between the exposure and control groups, they found significant differences at 30 and 365 days. The major mediators within the frailty group at 30 days were hospital length of stay (49%) and non-home discharge (16%), while mortality mediated only a 6% reduction. At 365 days, the effects of mortality became more pronounced, mortality was the major mediator (62%) of the frailty days at home association, followed by time in long-term care (40%) and length of stay (22%).

In other outcomes measured, such as 1-year survival, non-home discharge, and length of stay, this same relationship held true with an adjusted effect of 58% increased risk, 7% increased odds, and 56% more days, respectively, per 10% increase in pFI. Interestingly, though, the magnitude of effect of frailty on non-home discharge nearly vanished when covariance was adjusted for. This decreased the effect from a 137% increase per 10% increase in pFI to only a 7% increase in non-home discharge.

Discussion

This study demonstrated a clear association between preoperative frailty, as measured by the pFI, and a reduced number of days alive at home in the month and year after cardiac surgery. The direct correlation between increasing pFI and reduced DAH, with each 10% increase in pFI being associated with a 20% decrease in DAH in the month after surgery, gives us another way to help inform the preoperative conversation in older patients. Unlike previous studies that focused on mortality, a patient-centered metric such as days alive-at-home can help to clarify a vital aspect of the post-operative course in this patient population. Specifically, it can help us cater the conversation about risks associated with cardiac surgery to older patients in a way that is reflective of their desire to avoid severe cognitive and functional impairment, which to many will play a greater role in deciding on a given therapy compared to mortality.

One of the unique aspects of cardiac surgery that makes these conversations more difficult is the potential for significant prolonged functional improvement from fixing underlying cardiac disease paired with the potential for significant functional decline from surgical and post-operative factors. One of the key postoperative factors in older patients is functional decline as a result of hospitalization. It has been found that 41% of patients over 70 years old report

functional decline at discharge after hospitalization, with one of the underlying reasons being that the loss of ability to function normally associated with being hospitalized predisposes older patients to reduced functional independence at discharge. If we want to provide the most useful information on outcomes for older patients, a thorough understanding of the post-operative course and its associated impacts on functional independence is crucial. Given these competing factors when discussing the risks and benefits of cardiac surgery, it is also uniquely positioned to benefit from the utilization of a preoperative risk stratification tool such as the pFI in conjunction with quantifiable data on the postoperative course for patients from each stratum, which the days alive at home metric helps to provide. As physicians, it is our job to empower patients to make decisions that are well informed and align with their goals. Utilization of a preoperative risk stratification tool such as a frailty index and post-operative outcomes data on days alive at home after surgery are powerful tools to help us do this.

Without doubt, further study is needed to better understand the relationship between preoperative frailty and postoperative course in a more generalizable fashion. One of the key limitations of this study were geographic constraints, given that only data from the Ontario healthcare system was utilized. With further study of varying populations, the associations highlighted in this study could be evaluated over a broader, more diverse study group to help better understand frailty and the impact it has on post-operative course.

References

1. Fried, Terri R., et al. "Understanding the Treatment Preferences of Seriously Ill Patients." *New England Journal of Medicine,* vol. 346, no. 14, 2002, pp. 1061-1066., **https://doi.org/10.1056/nejmsa012528**.
2. McIsaac, Daniel I., et al. "Association of Frailty with Days Alive at Home after Cardiac Surgery: A Population-Based Cohort Study." *British Journal of Anaesthesia,* vol. 126, no. 6, 2021, pp. 1103–1110., **https://doi.org/10.1016/j.bja.2021.02.011**.
3. Kim, Dae Hyun, et al. "Preoperative Frailty Assessment and Outcomes at 6 Months or Later in Older Adults Undergoing Cardiac Surgical Procedures." *Annals of Internal Medicine,* vol. 165, no. 9, 2016, p. 650., **https://doi.org/10.7326/m16-0652.**
4. Kleinpell RM, Fletcher K, Jennings BM. Reducing Functional Decline in Hospitalized Elderly. In: Hughes RG, editor. Patient Safety and Quality: An Evidence-Based Handbook for Nurses. Rockville (MD): Agency for Healthcare Research and Quality (US); 2008 Apr. Chapter 11.

Incidence, Causes, and Outcomes Associated with Urgent Implantation of a Supplementary Valve During Transcatheter Aortic Valve Replacement

Landes U., Witberg G., Sathananthan J., et al *JAMA Cardiol.* 2021 Aug1;6(8):936-944. doi: 10.1001/jamacardio.2021.1145

Reviewer:

Liliya Pospishil MD
Assistant Professor
Department of Anesthesiology, Perioperative Care, and Pain Medicine
NYU Grossman School of Medicine

Background

Over the last two decades, transcatheter aortic valve replacement (TAVR) has been universally accepted as a treatment option for patients with severe symptomatic aortic stenosis. Although initially developed as therapy for patients who are at high surgical risk, robust clinical trials have lead to United States Food and Drug Administration TAVR approval in all surgical risk groups.[1] While improvements in device engineering and operator experience largely account for the success of TAVR, suboptimal device performance can occur secondary to various patient and procedural factors. TAVR failure is often managed by urgent implantation of supplementary valve during single procedure. Currently, data examining 2-valve TAVR (2V-TAVR) clinical outcomes is scarce. This study aimed to evaluate incidence, causes, and outcomes of TAVR when supplementary valve is needed during the procedure.[2]

Study Design

This study was a retrospective observational cohort study of patient data gathered from Redo-TAVR registry. Briefly, Redo-TAVR registry was designed to collect data on patients who underwent additional TAVR for transcatheter valve dysfunction from 2010 through February 2019 from 37 centers in Northern America, Europe, and the Middle East. In this study, data on 223 consecutive patients who underwent 2V-TAVR was collected from 16 participating centers, and data from 12 052 patients who underwent 1V-TAVR (without use of second device; control group) was collected from 15 participating centers from January 1, 2014, through February 2019. Patients with missing 30-day follow-up or data inconsistencies were excluded. For each valve, data on implantation date, model, and size was collected. Baseline aortic valve area, mean and maximal gradients, and degree and mechanism of regurgitation were gathered form echocardiographic studies before the index procedure and at 30 days and 1 year later. Outcome data collection was assessed according to the Valve Academic Research Consortium 2 (VARC-2) definitions and the second valve implantation was at the discretion of the operator (and reported by each site by review of procedural records and/or angiographic images). The principal endpoints were defined as mortality at 30 days and 1 year. Secondary end points were device success (2V-TAVR correct positioning, mean PG <20 mmHg, less than moderate aortic regurgitation (AR), freedom from coronary obstruction, tamponade, or annular rupture), stoke, myocardial infarction, acute kidney injury (AKI), major vascular complication, major vascular bleeding, new permanent pacemaker, open

heart surgery, and NYHA class III/IV. Valves were classified as early-generation (Sapien XT, CoreValve, Lotus, Portico) or newer-generation (all other models), repositionable (Evolut-R, Evolut-Pro, Portico, LOTUS, LOTUSEdge, Allegra) or nonrepositionable (all other models), balloon-expandable (Edwards valve family) or self-expending (all other models) devices.

Results

A total of 213 2V-TAVR and 10 010 1V-TAVR patients were studied with mean follow-up of 991 days. Baseline characteristics (age, sex, STS risk) were similar between the groups. Furthermore, rates of frailty and most comorbidities were similar, excluding that of atrial fibrillation (AF) (33.1% in 2V-TAVR vs 25% in 1V-TAVR) and LVEF <35% (12.4% in 2V-TAVR vs 7.8% in 1V-TAVR). Mean aortic valve area and pressure gradients were similar between the groups while incidence of AR moderate or greater was significantly higher and incidence of bicuspid aortic valve was numerically higher in 2V-TAVR group. The incidence of 2V-TAVR decreased from 2.9% in 2014 to 1% in 2018. The rate of alternative access and early-generation models was higher before 2016. While there was no difference in the use of repositionable valves between the groups, the use of self-expanding valves was significantly higher in 2V-TAVR group. Patient characteristics independently associated with 2V-TAVR included bicuspid aortic valve, moderate or greater AR, and AF. Alternative access, early generation valves, and self-expandable valves were identified as procedural factors independently associated with 2V-TAVR.

In 80% of cases, residual AR after incorrect positioning of primary valve was the reason for supplementary valve implantation. Incorrect valve position was too aortic in 45.4% of patients, and too ventricular in 34.3% of patients. Primary valve dysfunction most presented as AR with paravalvular leak being the cause in 53.2% of cases. Specific reasons for primary valve dysfunction were reported in 36 patients included post dilation, inappropriate fluoroscopic visualization, pacing failure, sizing errors, absence of calcifications, adverse root anatomy, and resuscitation.

The primary outcome of 30 day and 1 year mortality was higher in 2V-TAVR. The hazard ratio for mortality was 2.58 at 30 days and 1.45 at 1 year. Factors independently associated with mortality at 1 year after 2V-TAVR included alternative access, primary valve malposition, coronary obstruction, major bleeding, and AKI.

In matched 2V-TAVR and 1V-TAVR cohorts, 30-day device success was attainted in 70.4% and 92.2% (P <0.001) of patients. Although not statistically significant, the 30-day incidence of coronary obstruction, stroke, major bleeding, and annular rupture was higher in patients undergoing 2V-TAVR and incidence of AKI, major vascular complication, and new permanent pacemaker were similar between the groups. At 1 year follow-up, no significant difference was seen in mean pressure gradient, residual moderate or greater AR, or NYHA III/IV class.

Discussion

Despite advances in technology (more stable delivery systems, better paravalvular sealing systems), operator experience, and improved patient selection correct and successful valve deployment remains a challenge and device failure may occur, most commonly presenting as significant AR. Implantation of overlapping supplementary valve that extends the seal around the annulus can decrease severity of AR and restore normal prosthetic leaflet

function. Although effective, 2V-TAVR can be potentially dangerous.

This study is the most current analysis of 2V-TAVR series highlighting several important findings. First, 2V-TAVR incidence decreased overtime, from 3% in 2014 to 1% in 2018. The temporal reduction in incidence is comparable to recent data from Society of Thoracic Surgeons/American College of Cardiology Transcatheter Valve Therapy registry.[3] This trend likely reflects learning curve and advances in TAVR such as fabric sealing cuffs in newer-generation valves facilitating reliable sealing.

Second, malposition of primary valve with residual paravalvular leak is the most common indication for supplementary valve. Independent risk factors for 2V-TAVR include bicuspid aortic valve, presence of AR, the use of balloon-expandable valve, and alternative access. Interestingly, the use of repositionable valves did not mitigate the risk of 2V-TAVR. These findings are in accordance with prior studies identifying bicuspid aortic valves and regurgitant aortic valves as carrying increased risk of residual regurgitation and procedural failure.[4,5,6] Meticulous procedural planning, taking into account risk factors for device malfunction, is imperative to procedure success.

Third, 2V-TAVR is associated with higher mortality, and burden of complications compared with 1V-TAVR with several factors (alternative access, valve malposition, major bleeding, annular rupture, coronary obstruction, and AKI) associated with increased 1 year mortality following 2V-TAVR. Increase in mortality occurred despite 70% of cases achieving hemodynamic function similar to that of 1V-TAVR. In subgroup analysis, mortality was also higher in patients with primary valve malposition as an indication for 2V-TAVR. It is likely that worse outcomes are driven by the misplacement of primary valve rather than the use of supplementary valve. Alternative procedural access was associated with higher mortality which is comparable to findings published in numerous other studies.

This is a large observational cohort study; however, its retrospective design has several limitations, including inability to examine temporal relationship and causation. Although propensity score matching is a widely accepted approach in observational research, it does not control for unmeasured bias. The indication for 2V-TAVR was based on operator's decision without clear predetermined criteria which introduces great variability into the data set. All procedures were performed at large TAVR centers with experienced teams and thus findings cannot be applied to smaller, less experienced TAVR programs for which the risk may be underestimated. Finally, data on alternative management for valve dysfunction was not captured (including surgery or medical management) and long-term durability and coronary access difficulty could not be examined due to limited follow-up.

Despite these limitations, this study is a valuable contribution to the literature examining incidence, indications, and outcomes following 2V-TAVR. Valve malposition was identified as the most common indication for 2V-TAVR with decreased incidence over time, reflecting both advances in technology and operator experience. However, patients with bicuspid aortic valve, aortic regurgitation, self-expandable valves, and alternative access are at increased risk of 2V-TAVR which carries higher burden of complications compared to 1V-TAVR. Additional research is needed to elucidate the long-term outcomes of 2V-TAVR, as well as alternative management strategies for treatment of device failure.

References

1. Sundt TM, Jneid H. Guideline Update on Indications for Transcatheter Aortic Valve Implantation Based on the 2020 American College of Cardiology/ American Heart Association Guidelines for Management of Valvular Heart Disease. *JAMA Cardiol.* 2021 Sep 1;6(9):1088-1089.
2. Landes U, Witberg G, Sathananthan J, et al. Incidence, Causes, and Outcomes Associated with Urgent Implantation of a Supplementary Valve During Transcatheter Aortic Valve Replacement. *JAMA Cardiol.* 2021 Aug 1; 6(8):936-944.
3. Carroll JD, Mack MJ, Vemulapalli S, et al. STS-ACC TVT Registry of Transcatheter Aortic Valve Replacement. *J Am Coll Cardiol.* 2020 Nov 24;76(21):2492-2516.
4. Heidari B, Al-Hijji MA, Alkhouli MA, et al. Transcatheter Aortic Valve Replacement Outcomes in Mixed Aortic Valve Disease Compared to Predominant Aortic Stenosis. *Int J Cardiol.* 2020 Jan 15;299:209-214. doi: 10.1016/j.ijcard.2019.07.099.
4. Heidari B, Al-Hijji MA, Alkhouli MA, et al. Transcatheter Aortic Valve Replacement Outcomes in Mixed Aortic Valve Disease Compared to Predominant Aortic Stenosis. *Int J Cardiol.* 2020 Jan 15;299:209-214. doi: 10.1016/j.ijcard.2019.07.099.
5. Yoon SH, Kim WK, Dhoble A, et al Bicuspid Aortic Valve Stenosis Transcatheter Aortic Valve Replacement Registry Investigators. Bicuspid Aortic Valve Morphology and Outcomes After Transcatheter Aortic Valve Replacement. *J Am Coll Cardiol.* 2020 Sep 1;76(9):1018-1030.
6. Clerfond G, Pereira B, Innorta A, et al. Comparison of outcomes after one-versus-two transcatheter aortic valve implantation during a same procedure (from the FRANCE2 Registry). *Am J Cardiol.* 2015 May 1;115(9): 1273-80.

10-year Follow-Up After Revascularization in Elderly Patients WIth Complex Coronary Artery Disease

Ono M, Serruys PW, Hara H, et al. 10-Year Follow-Up After Revascularization in Elderly Patients with Complex Coronary Artery Disease. *J Am Coll Cardiol.* 2021;77(22):2761-2773. doi:10.1016/j.jacc.2021.04.016

Reviewers:

Douglas Campbell, MD
Department of Anesthesiology & Perioperative Medicine
University of California, Los Angeles

Sophia P. Poorsattar, MD
Assistant Clinical Professor
Department of Anesthesiology & Perioperative Medicine
University of California, Los Angeles

Background

The leading cause of death among elderly patients is coronary artery disease (CAD), who tend to have more severe and/or complex disease as compared to younger patients. The American Heart Association (AHA) and Centers for Disease Control (CDC) heart disease and stroke statistics show a rapid increase in the population ≥65 years of age in conjunction with a decrease in the rate of slowing of heart disease related deaths. As a result, there has been an absolute increase in the number of heart disease related deaths, increasing by 8.5% since 2011.[1] Unfortunately, insufficient data exists to provide evidence-based recommendations for the elderly regarding the management of complex CAD, as trials have often excluded this patient population based on age/comorbidities. Accordingly, with the global population aging and average life expectancy increasing worldwide, it is pertinent more than ever to discuss optimal treatment strategies specific to elderly patients with complex CAD.

The authors present a 10-year follow up and subgroup analysis from the SYNTAX (Synergy between PCI with Taxus and Cardiac Surgery) and SYNTAXES (Synergy between PCI with Taxus and Cardiac Surgery Extended Survival) trial. The trials had very liberal inclusion and minimal exclusion criteria making them ideal to investigate complex CAD, defined by the authors as 3-vessel disease (3VD) or left main CAD (LMCAD), in elderly patients, defined as >70 years of age. Specifically, the authors looked at the revascularization strategy of percutaneous coronary intervention (PCI) versus coronary artery bypass grafting (CABG) on outcomes such as 10-year all cause death, 5-year major adverse cardiac or cerebrovascular events (MACCE) rates, and quality of life (QOL) indicators in the elderly and nonelderly cohorts.

Methods

The SYNTAX trial was a multicenter, randomized controlled trial completed in 85 hospitals with participants enrolled from 2005 to 2007. A total of 4,337 patients were evaluated, of which 1,800 patients were enrolled with de novo 3VD and/or LMCAD who were deemed eligible for PCI and CABG. The only exclusion criterion was patients presenting with acute myocardial infarction (MI). Prior to randomization, patients were subdivided into elderly (>70 years

of age) or nonelderly (≤ 70 years of age) and subsequently randomized 1:1 to PCI with TAXUS Express paclitaxel drug-eluding stents or CABG. The primary endpoint was 10-year all-cause mortality. Additionally, 5-year major adverse cardiac and cerebrovascular events (MACCE: all cause death, MI, stroke, repeated revascularization) and QOL indicators using a self-reported questionnaire (Seattle Angina Questionnaire) were assessed.

Results

The mean age of the elderly (n=575) group was 75.8 +/- 3.6 years compared to 60.1 +/- 7.4 years for the nonelderly (n=1,225). The elderly group had significantly more females than the nonelderly group (33.6% vs. 17.1%, p < 0.001) and had a higher prevalence of comorbid conditions such as congestive heart failure, chronic kidney disease, peripheral vascular disease, or cerebrovascular disease. In elderly patients, there was no significant difference between PCI versus CABG and the risk of 10-year all-cause death (44.0% vs. 41.5%; HR:1.08; 95% CI: 0.84 to 1.40; p=0.530). In nonelderly patients, PCI was associated with a higher risk for 10-year all-cause death (21.1% vs. 16.6%; HR: 1.30; 95% CI:1.00 to 1.69; p=0.052; p for interaction 0.332). In elderly patients, the risk of MACCE at 5 years was not different between PCI versus CABG (39.4% vs. 35.1%; HR: 1.18; 95% CI: 0.90 to 1.56; p=0.233) while in nonelderly patients, PCI was associated with a significantly higher risk for MACCE when compared to CABG (36.3% vs. 23.0%; HR: 1.69; 95% CI: 1.36 to 2.10; p <0.001; p for interaction 0.043). The mean restricted survival at 10 years in elderly patients treated with PCI and CABG was not significantly different with mean survival of 7.7 and 7.9 years and difference of 0.2 years (95% CI: -0.4 to 0.7 years; p=0.524). At 5 years, there was no difference between PCI and CABG for patients' health status indicators including angina frequency, physical limitation, treatment satisfaction, and QOL.

Discussion

The findings demonstrate that for elderly patients with complex CAD, with either PCI or CABG as an intervention strategy, there was no significant difference with regards to 10-year all-cause mortality, 5-year MACCE, or QOL indicators. In contrast, for nonelderly patients, there was a significantly increased risk of 5-year MACCE and a numerically increased 10-year all-cause death with PCI as the intervention. This risk-difference across both end points became smaller as age increased. Therefore, based on the authors' findings, they conclude that there is a known benefit to CABG over PCI in the nonelderly population but that this benefit does not apply to the elderly population.

The elderly populations studied had an increased prevalence of comorbid conditions and this could increase the risk of more invasive procedures for these patients and make a less invasive approach to revascularization more attractive. The authors do note that there is evidence to take an even less invasive approach, and to provide the elderly population with goal directed medical therapy (GDMT) which has been shown to be effective treatment for moderate to severe CAD via the ISCHEMIA trial. The ISCHEMIA trial showed no difference in their primary outcome of composite cardiovascular death, MI, or hospitalization for acute coronary syndrome between GDMT and revascularization.[2] One major difference between the ISCHEMIA trial and the current paper is the definition of complex CAD–moderate to severe reversible ischemia on stress testing versus 3VD and/or LMCAD, respectively.

A major strength of the study was the excellent long term follow up over a 10-year period, with a follow up rate of 94.3% (1,689 of 1800). Additionally, the

minimal exclusion criteria allowed complex CAD to be assessed in the elderly population, a population that has gone understudied. One limitation of the current study is that the results are only generalizable to elderly individuals with complex CAD who are deemed eligible for both PCI and CABG as this was the population studied. Another limitation is that data from the study was collected on patients enrolled from 2005 to 2007 with the use of TAXUS Express paclitaxel drug-eluding stents, and stent technology has improved since that time. Given the nature of long-term follow up, avoiding outdated technology is not typically feasible. A final limitation is that defining elderly is subjective and inconsistent among studies with variable age cutoffs used. This particular study identified individuals >70 years of age as elderly; in contrast, data from the AHA and CDC often define elderly as ≥65 years of age. In general, this highlights a major challenge to the comparison of clinical studies of elderly individuals: variable definitions of elderly as well as ever increasing life expectancy.

References

1. Virani SS, Alonso A, Aparicio HJ, Benjamin EJ, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Cheng S, Delling FN, et al.; on behalf of the American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics—2021 update: a report from the American Heart Association. *Circulation.* 2021;143:e254–e743.
2. Maron DJ, Hochman JS, Reynolds HR, et al. Initial Invasive or Conservative Strategy for Stable Coronary Disease. *The New England Journal of Medicine.* 2020;382(15):1395-1407.

PRO CON

PRO/CON DEBATE

In this issue of the SCA newsletter a Pro-Con discussion on Cerebral Oximetry is presented. The following is a description of cerebral oximetry using near infrared spectroscopy

Andrew Maslow, MD

Cerebral oximetry (rSO2) uses near-infrared spectroscopy (NIRS) to non-invasively monitor cerebral oxygenation. The principle is the same that guides pulse oximetry. The device consists of adhesive pads containing probes with light emitting diodes (LED) that transmit light in the infrared range (700-1000nm). Infrared light penetrates the skull and passes to the cerebral cortex, or in the case of cerebral oximeters, the frontal lobe cortex. The transmitted light is absorbed by metal chromophores found in hemoglobin. Infrared light is absorbed by oxygenated hemoglobin. Otherwise, light is refracted, reflected, or scattered. The reflected light returns to the light detectors and is inversely correlated with the amount of light absorbed.

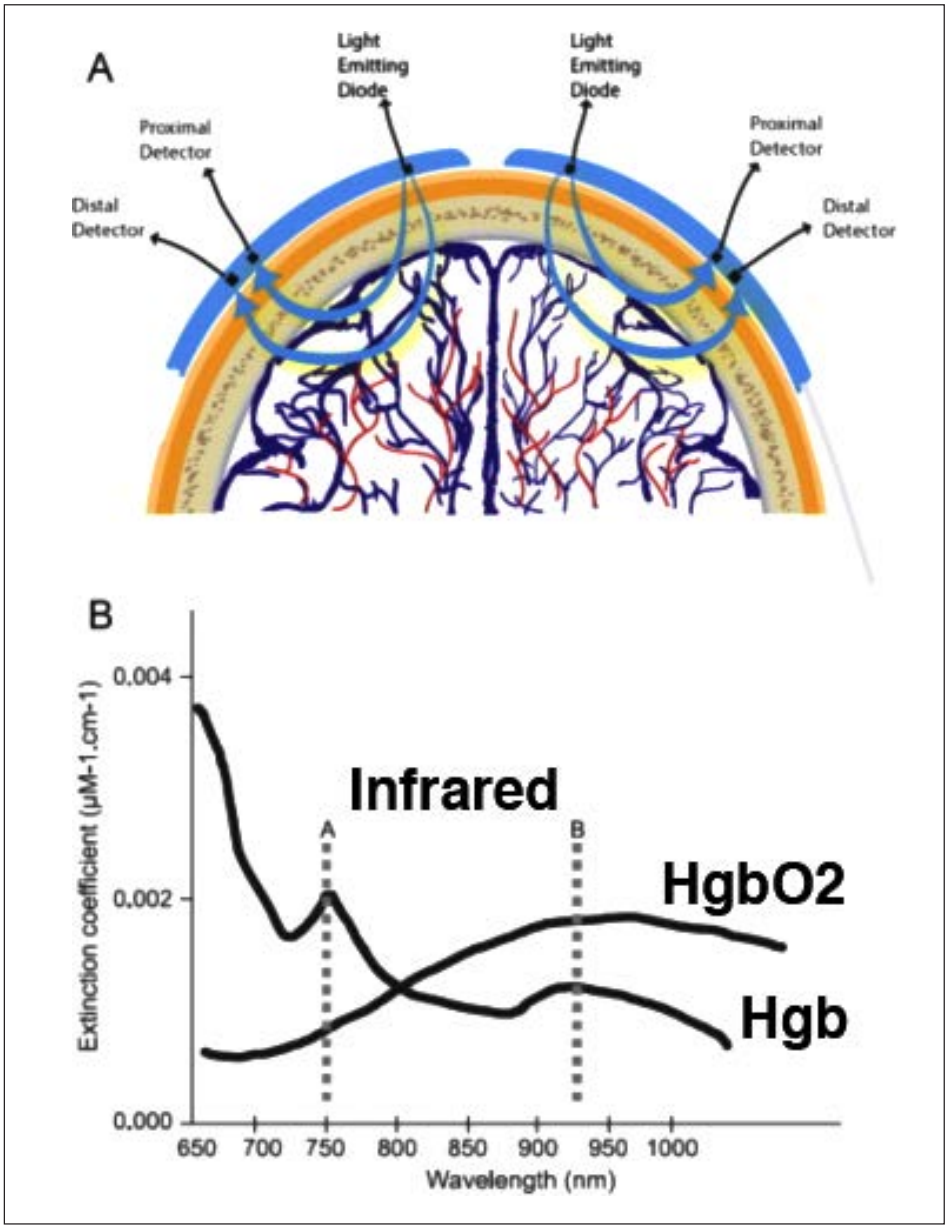
Infrared light (> 700 nm; 960nm) is absorbed more by oxygenated hemoglobin while red light (< 700 nm; 660nm) is absorbed more by deoxygenated hemoglobin. Using the Beer and Lambert or Beer-Lambert law, oxygen saturation, or the absorbed light, is calculated. Beer Law states that the intensity of a transmitted light declines with increasing concentration substance light is traveling through. Lambert Law states that the intensity of a transmitted light declines with increasing distance of the substance light is traveling through.

In order to account for variable distances between the light emitters and the brain tissue, oximeters use mathematical algorithms to avoid sampling near field fluids or blood, which would alter absorbances. As there are different cerebral oximeter devices from different companies, there exist variability and different algorithms to detect tissue absorbance of infrared light. Nevertheless, cerebral oximeters, based on the absorbance of infrared light measure the amount of oxygenated hemoglobin at the tissue level. The recorded value is a percentage of light absorbed by oxygenated hemoglobin to amount of light absorbed by total hemoglobin. Compared to pulse oximetry, cerebral oximeters are mostly (approximately 70%) determining the absorbance, or oxygen saturation, of venous blood, and thus there is no pulsatility seen. As such, cerebral oximetry is not a measure of tissue perfusion, but more so a measure of balance between oxygen demand and balance.

Normal values range from 60-80%, but values as low as 55% may be considered normal. Due to patient variability, baseline data should be obtained to allow monitoring of percentage changes thereafter. Assuming that cerebral oxygen saturations represent a balance between oxygen delivery and consumption, the oximeter is able to continuously measure tissue perfusion and metabolism. Since right and left frontal lobe perfusion may differ due to either patient anatomical variations or the details of the procedure, oximeter sensors are placed on the right and left forehead, i.e., bilateral monitoring.

Limitations of cerebral oximetry include the presence of extracranial blood or tissue edema that alters absorbance of emitted infrared light. Other sources of interference include motion, external light, dyes, bilirubin, and greater distance between the emitter and tissue. To reduce interference the sensors should be as close to the surface as possible, motionless, and perhaps covered to shield from external interferences.

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation



Reprinted with permission from Steppan J, Hogue CW Jr: Cerebral and tissue oximetry. Best Pract Res Clin *Anaesthesiol.* 2014;28(4):429-439. doi:10.1016/j.bpa.2014.09.002

Tosh W, Patteril M: Cerebral oximetry. *BJA Education.* 2016;16:417-421. doi: 10.1093/bjaed/mkw024

Steppan J, Hogue CW Jr: Cerebral and tissue oximetry. *Best Pract Res Clin Anaesthesiol.* 2014;28(4):429-439. doi:10.1016/j.bpa.2014.09.002

Ferrari M, Giannini I, Sideri G, Zanette E. Continuous non invasive monitoring of human brain by near infrared spectroscopy. *Adv Exp Med Biol.* 1985;191:873-882. doi:10.1007/978-1-4684-3291-6_88

Murkin JM, Arango M: Near-infrared spectroscopy as an index of brain and tissue oxygenation. *Br J Anaesth.* 2009;103 Suppl 1:i3-i13. doi:10.1093/bja/aep299

PRO/
CON
DEBATE

Routine Use of Cerebral Oximetry in Cardiac Surgery

PRO

Scott Creel, MD
Mario Flores, MD, MBA
Arunthevaraja Karuppiah MBBS, MD
Mark Nelson MD, M.Ed
Department of Anesthesiology
Virginia Commonwealth University
Richmond, Virginia

INTRODUCTION

The human brain due to its high oxygen utilization is extremely susceptible to hypoxemia mediated injury.[1] Yet, intraoperative neuromonitoring remains unstandardized in cardiac surgery. Neurologic injury is a devastating complication which contributes to significant morbidity and mortality.[2] The most common etiologies of brain injury after cardiac surgery are embolic in origin or due to perfusion related injuries which are less understood. Injuries resulting from the latter often occur despite well maintained global circulatory parameters during cardiac surgery suggesting an etiology related to imbalances in cerebral microcirculation.

NIRS

Noninvasive infrared spectrometry (NIRS) is a cerebral oximetry monitor/method with utilizes near infra-red light to penetrate the skull and determine relative concentration of oxyhemoglobin and deoxyhemoglobin, based on modified Beer Lambert law. NIRS allows non-invasive (rScO2), continuous, and real-time monitoring of regional cerebral oxygen saturation at microcirculatory level in the frontal cerebral cortex.[3] rScO2 values range from 0-100 and are utilized as a surrogate of the oxygen/supply demand in the vulnerable watershed region of the frontal cerebral cortex and hence provide a sensitive method of detecting changes in oxygen delivery. NIRS thus may serve as an "early warning sign" of decreased oxygen delivery to the entire brain and eventually other major organs. Inherent advantages of cerebral oximetry include relative insensitivity to anesthetic agents as well as not requiring pulsatile flow for interpretation making it useful during cardiopulmonary bypass (CPB).[4] It should be noted, NIRS does not provide direct information about the middle and posterior cerebral microcirculation5. NIRS differs from pulse oximetry in that tissue sampling represents primarily (70-75%) venous blood oxygenation, and less (20-25%) arterial blood. Unlike pulse oximetry which uses the light absorption during diastole as its baseline, NIRS utilizes a second reflected signal assumed to be extracranial as its background or baseline. NIRS measurements should be interpreted in the context of the preinduction awake baseline value, patient-specific, and disease specific characteristics as well as alterations of physiologic variables which may be relevant.

NEUROCOGNITIVE OUTCOMES

Use of NIRS in non-cardiac surgery patients has demonstrated that reductions in rScO2 are common and that these reductions might be associated with an increase in postoperative cognitive dysfunction.[6] Evidence supports those interventions to correct cerebral desaturations resulted in better neurocognitive outcome during cardiac,[7] orthopedic surgery in sitting position,[8] and during

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

implantation of left ventricular assist device (LVAD) and extracorporeal membrane oxygenation (ECMO).[9] These findings were reaffirmed by a 2020 study in cardiac surgery patients which demonstrated patients had better memory scores in the group utilizing NIRS at six months follow-up.[10]

TREATMENT ALGORITHMS

A treatment algorithm proposed by Denault et al. more than a decade ago for reversal of cerebral desaturation continues to be widely utilized as well as other newer treatment algorithms have also been adopted.[11] The Canadian Perioperative Anesthesia Clinical Trials Group undertook a randomized controlled feasibility trial which demonstrated that reversal of 10% or greater desaturations was feasible in 97% of patients undergoing high-risk cardiac surgery.[12] Another multicenter study by Subramanian et al. which included 235 patients undergoing coronary artery bypass graft and/or valvular surgery found similarly that an intervention algorithm can reverse most desaturations (decrements >20%, 92% rate of reversal).[13]

AORTIC ARCH SURGERY

NIRS has shown efficacy in deep hypothermic circulatory arrest utilizing anterior cerebral perfusion (ACP) in identifying hemispheric deficits in perfusion. Treatments included modification of ACP techniques, increasing pressures or flows, and repositioning cannulas.[14,15] Desaturations greater than 20% of baseline values were associated with postoperative neurologic dysfunction[4] and other complications including increased hospital length of stay (LOS).[16] In another study on patients undergoing aortic arch surgery, information provided by NIRS was found to be instrumental in guiding cannula position to provide the best cerebral oximetry.[17]

ON PUMP CARDIAC SURGERY

Multiple studies have shown that low baseline rScO2 values are associated with worse neurologic outcomes, and this may be a marker of frailty.[17-19] Further, prolonged desaturations during cardiopulmonary bypass have been associated with worse early and late neurologic dysfunction.[18,20] The NORMOSAT trial demonstrated that interventions which improved intraoperative cerebral saturation translated to increases in postoperative cerebral saturation as well.[21] In addition to neurological outcomes, use of NIRS has been shown to predict and reduce major organ dysfunction and morbidity and reduce ICU and hospital LOS.[14,17,22] Lastly, there are multiple case reports demonstrating that cerebral oximetry can help identify catastrophic malperfusion events secondary to cannula or clamp misplacement.[17] Use of NIRS to elucidate specific cerebral autoregulatory curves for CPB perfusion pressures is feasible.[17,23,24] While the data may not be conclusive that use of cerebral oximetry reduces postoperative cognitive dysfunction, there is data that supports the use of NIRS technology to reduce multi organ dysfunction.[25]

OFF PUMP

Most of the data supporting cerebral oximetry use in off-pump coronary artery bypass surgery is extrapolated from on-pump data, but there is some data to support that cerebral desaturation is associated with increased delirium, acute kidney injury, increased ICU and hospital LOS in off-pump surgery.[26] Given the degree of the manipulation of the heart while performing off-pump coronary bypass grafting (OPCAB), abrupt decrease in cardiac output and subsequent decrease in cerebral perfusion can occur. NIRS has the potential to detect cerebral hypoperfusion in these instances and may reduce the frequency of adverse neurologic outcomes after OPCAB.

PRO

MECHANICAL CIRCULATORY DEVICES

Because of the non-pulsatile nature of commonly used mechanical cardiac devices including LVADs and ECMO, use of monitors such as pulse oximetry is limited. Other methods to monitor oxygenation, such as arterial blood gases are cumbersome, time consuming and may not provide results in real time. Use of NIRS in these circumstances would be an appealing alternative. Additionally, stroke remains a significant risk for LVAD patients with more than 10% of patients having one or more strokes according to an analysis of INTERMACS data from May 2012 to March 2015.[27] While many studies have not demonstrated a difference in clinical stroke occurrence in patients undergoing cardiac surgery with and without cerebral oximetry monitoring interventions, the subset of LVAD patients was largely excluded. One study suggests a greater baseline cerebral saturation in patients after LVAD placement is associated with a decreased 30-day mortality rate.[28] In another study, longer durations of cerebral desaturations and minimums values were associated with new cerebral lesions on diffusion weighted MRI.[29] Identifying those at great risk for stroke and intervening may decrease either frequency or severity of strokes for patients undergoing LVAD surgery.

PEDIATRIC CARDIAC SURGERY

Infants and neonates undergoing cardiac surgery are a tenuous patient population predisposed to a substantial morbidity and mortality secondary to complex surgical procedures and concomitant disease processes. Multiple studies have demonstrated that low NIRS values are associated with new ischemic cerebral lesions on MRI30. In one study, 25% of patients who had a significant monitoring event (including cerebral oximetry desaturation) which was not addressed, had increased neurologic sequela compared to patients who did not have an event or had an event that was treated. This study found that low cerebral oximetry values were associated with increased ICU LOS, increased use of ECMO and death.[30] In addition to associative data, interventions treating decreased cerebral oxygenation reduced postoperative neurologic events.[23] Lastly, given the complexity of anatomy in this patient population, cerebral oximetry has been shown to help identify malperfusion secondary to clamp misplacement, cannula misplacement, or previously undetected aortopulmonary collaterals.[31]

TAVR

Given the complexity of patients undergoing transcatheter approaches to aortic valve replacement and the risk of CVA associated with these procedure, cerebral oximetry may provide valuable information in patient management. Cerebral oximetry has been successfully utilized to provide information on the patency of the Circle of Willis during trans-carotid approaches to TAVR.[32] There is data to support cerebral oximetry use during cardiopulmonary resuscitation demonstrating that cerebral oximetry values are be superior to or provide valuable information in addition to end tidal CO2 monitoring in predicting ROSC.[17,33-35]

CONCLUSION

There is currently limited consensus in defining adverse neurologic outcomes and critical levels of ScO2 (relative vs. absolute values). Further refinement may allow for more meaningful studies of monitoring and intervention utilizing cerebral oximetry as it relates to neurologic and other outcomes. While medical societal consensus and recommendations are ideal for standardizing management, their absence does not equate to their opposition to a technology such as NIRS. This debate in this issue of the newsletter is not determined by an overwhelming preponderance of data answering the question, but rather noting that current studies do not provide

PRO

an answer. Like a jury dealing with a human life, medicine needs certainty beyond a reasonable doubt to refute a practice or technology which may ultimately be useful. In the case of NIRS, this level of certainty has not occurred. The jury is hung and until new evidence is introduced, we cannot send NIRS to the gallows. To abandon this technology would be to assume its guilt. Until more definitive studies are completed, we must continue to study NIRS and practice with prudence, offering patients the potential benefits of NIRS for which there is little downside beyond cost. This approach is not new to medicine and can be seen with ICP monitoring in severe TBI as well as pulse oximetry as a standard of care in anesthesia.[30,36] For cerebral oximetry, its use is less determined by medical societal standards but rather what we believe might be beneficial and should be used in most cardiac surgical procedures.[37] After all, it may not be as simple as use of cerebral oximetry but rather how it is used that alters patient outcomes. This "how" may still have eluded us. As future research continues, the universal use of this technology in cardiac surgery is almost certain to follow.

References

1. Murkin JM. Cerebral oximetry: monitoring the brain as the index organ. *Anesthesiology.* 2011;114(1):12-13.
2. Slater JP, Guarino T, Stack J, et al. Cerebral oxygen desaturation predicts cognitive decline and longer hospital stay after cardiac surgery. *Ann Thorac Surg.* 2009;87(1):36-44; discussion 44-35.
3. Steppan J, Hogue CW, Jr. Cerebral and tissue oximetry. *Best Pract Res Clin Anaesthesiol.* 2014;28(4):429-439.
4. Tsaousi G, Tramontana A, Yamani F, Bilotta F. Cerebral Perfusion and Brain Oxygen Saturation Monitoring with: Jugular Venous Oxygen Saturation, Cerebral Oximetry, and Transcranial Doppler Ultrasonography. *Anesthesiol Clin.* 2021;39(3):507-523.
5. Ali J, Cody J, Maldonado Y, Ramakrishna H. Near-Infrared Spectroscopy (NIRS) for Cerebral and Tissue Oximetry: Analysis of Evolving Applications. *J Cardiothorac Vasc Anesth.* 2021.
6. Nielsen HB. Systematic review of near-infrared spectroscopy determined cerebral oxygenation during non-cardiac surgery. *Front Physiol.* 2014;5:93.
7. Colak Z, Borojevic M, Bogovic A, Ivancan V, Biocina B, Majeric-Kogler V. Influence of intraoperative cerebral oximetry monitoring on neurocognitive function after coronary artery bypass surgery: a randomized, prospective study. *Eur J Cardiothorac Surg.* 2015;47(3):447-454.
8. Trafidlo T, Gaszynski T, Gaszynski W, Nowakowska-Domagala K. Intraoperative monitoring of cerebral NIRS oximetry leads to better postoperative cognitive performance: a pilot study. *Int J Surg.* 2015;16(Pt A):23-30.
9. Maldonado Y, Singh S, Taylor MA. Cerebral near-infrared spectroscopy in perioperative management of left ventricular assist device and extracorporeal membrane oxygenation patients. *Curr Opin Anaesthesiol.* 2014;27(1):81-88.
10. Uysal S, Lin HM, Trinh M, Park CH, Reich DL. Optimizing cerebral oxygenation in cardiac surgery: A randomized controlled trial examining neurocognitive and perioperative outcomes. *J Thorac Cardiovasc Surg.* 2020;159(3):943-953 e943.
11. Denault A, Deschamps A, Murkin JM. A proposed algorithm for the intraoperative use of cerebral near-infrared spectroscopy. *Semin Cardiothorac Vasc Anesth.* 2007;11(4):274-281.
12. Deschamps A, Hall R, Grocott H, et al. Cerebral Oximetry Monitoring to Maintain Normal Cerebral Oxygen Saturation during High-risk Cardiac Surgery:

A Randomized Controlled Feasibility Trial. *Anesthesiology.* 2016;124(4):826-836.

13. Subramanian B, Nyman C, Fritock M, et al. A Multicenter Pilot Study Assessing Regional Cerebral Oxygen Desaturation Frequency During Cardiopulmonary Bypass and Responsiveness to an Intervention Algorithm. *Anesth Analg.* 2016;122(6):1786-1793.
14. Thiele R, Shaw A, Bartels K, et al. American Society for Enhanced Recovery and Perioperative Quality Initiative Joint Consensus Statement on the Role of Neuromonitoring in Perioperative Outcomes: Cerebral Near-Infared Spectroscopy. *Anesthesia.* 2020;131(5):1444-1455.
15. Yu Y, Lyu Y, Jin L, et al. Prognostic Factors for Permanent Neurological Dysfunction After Total Aortic Arch Replacement with Regional Cerebral Oxygen Saturation Monitoring. *Brain and Behavior.* 2019;9(7).
16. Fischer GW, Lin HM, Krol M, et al. Noninvasive cerebral oxygenation may predict outcome in patients undergoing aortic arch surgery. *J Thorac Cardiovasc Surg.* 2011;141(3):815-821.
17. Green D, Kunst G. Cerebral Oximetry and its role in adult cardiac, non-cardiac surgery and resuscitation from cardiac arrest. *Anaesthesia.* 2017;72:48-57.
18. Semrau J, Motamed M, Ross-White A, Boyd J. Cerebral Oximetry and Preveting Neurological Complication Post Cardiac-Surgery: A Systematic Review. *European Journal of Cardio-Thoracic Surgery.* 2021;59:1144-1154.
19. Lei L, Katznelson R, Fedorko L, et al. Cerebral Oximetry and postoperative delerium after cardiac surgery: a randomized control trial. *Anaesthesia.* 2017;72:1456-1466.
20. Bennett S, Smith N, Bennett M. Cerebral Oximetry in Adult Cardiac Surgery to Reduce the Incidence of Neurological Impairment and Hospital Length-of-Stay: A Prospective, Radnomized, Control Trial. *Journal of the Intensive Care Society.* 2020;0(0):1-8.
21. Deschamps A, Hall R, Grocott H, et al. Cerebral oximetry monitoring to maintain NORMal Cerebral Oxygen SATuration during high-risk cardiac surgery: a randomized controlled feasibility trial. *Anesthesiology.* 2016;124(4):826-836.
22. Douds M, Straub E, Bistrick C, Sistino J. A Systematic REview of Cerebral Oxygenation-Monitoring Devices in Cardiac Surgery. *Perfusion.* 2014;29(6):545-552.
23. Steppan J, Hogue C. Cerebral and Tissue Oximetry. *Best Practice and Research Clinical Anaesthesiology.* 2014;28:429-439.
24. Scheeren T, Kuizenga M, Maurer H, Struys M, Heringlake M. Electroencephalography and Brain Oxygenation Monitoring in the Perioperative Period. *Anesthesia and Analgesia.* 2019;128(2):265-277.
25. Mailhot T, Cossette S, Lambert J, Cournoyer A, Denault A. Cerebral Oximetry as a Biomarker of Postoperative Delerium in Cardiac Surgery Patients. *Journal of Critical Care.* 2016;34:17-23.
26. Lim L, Nam K, Lee S, et al. The relationship between intraoperative cerebral oximetry and postoperative delirium in patients undergoing off-pump coronary artery bypass graft surgery: a retrospective study. *BMC Anesthesiology.* 2020;20(1):285.
27. Acharya D, Loyaga-Rendon R, Morgan CJ, et al. INTERMACS Analysis of Stroke During Support With Continuous-Flow Left Ventricular Assist Devices: Risk Factors and Outcomes. *JACC Heart Fail.* 2017;5(10):703-711.

28. Ghosal S, Trivedi J, Chen J, et al. Regional Cerebral Oxygen Saturation Level Predicts 30-Day Mortality Rate After Left Ventricular Assist Device Surgery. *J Cardiothorac Vasc Anesth.* 2018;32(3):1185-1190.
29. Holmgaard F, Vedel AG, Langkilde A, Lange T, Nilsson JC, Ravn HB. Differences in regional cerebral oximetry during cardiac surgery for patients with or without postoperative cerebral ischaemic lesions evaluated by magnetic resonance imaging. *Br J Anaesth.* 2018;121(6):1203-1211.
30. Kasman N, Brady K. Cerebral Oximetry for Pediatric Anesthesia: Why do Intelligent Clinicians Disagree. *Pediatric Anesthesia.* 2011;21:473-478.
31. Frogel J, Kogan A, Augoustides H, et al. The Value of Cerebral Oximetry Monitoring in Carduac Surgery: Challenges and Solutions in Adult and Pediatric Practice. *Journal of Cardiothoracic and Vascular Anesthesia.* 2019;33:1778-1784.
32. Del Trigo F, Rodes-Cabau J, Dumont E, et al. A Novel Transcarotid Approach for Implantation of Baloon-Expandable or Self-Expandable Transcatheter Aortic Valves. *Canadian Journal of Cardiology.* 2016;32.
33. Liu Y, Jing K, Liu H, et al. Association between cerebral oximetry and return of spontaneous circulation following cardiac arrest: A systematic review and meta analysis. *PLOS One.* 2020;15(8).
34. Sanfilippo F, Serena G, Corredor C, et al. Cerebral Oximetry and return of spontaneous circulation after cardiac arrest: a systematic review and meta analysis. *Resuscitation.* 2015;94:67-72.
35. Engel T, Thomas C, Medado P, et al. End Titdal CO2 and Cerebral Oximetry for the Prediction of Return of Spontaneous Circulation During Cardioipulmonary Resuscitation. *Resuscitation.* 2019;139:174-181.
36. Zhao X, Xiao H, Cai J, Meng L. Double standards: why is pulse oximetry standard care, whereas tissue oximetry is not? *Curr Opin Anaesthesiol.* 2020;33(5):619-625.
37. Marymont J, Shear T, Novak T. Is Cerebral Oximetry Monitoring a Standard-of-Care During Cardiac Surgery. *Journal of Cardiothoracic and Vascular Anesthesia.* 2021;35:3139-3149.

PRO/
CON
DEBATE

Cerebral Oximetry: Routine Use in Cardiac Surgery Is Not Supported

CON

Christopher Halline BA
Shyamal Asher MD MBA
Caroline Hunter MD
Andrew Maslow MD

Neurocognitive dysfunction, grouped into Type 1 (stroke) and Type 2 (neurocognitive dysfunction, delirium, seizures), occurs in up to 5% to 40% of cardiac surgical patients respectively, and is associated with increased morbidity and mortality.[1,2,3] Known risk factors include increasing age, hypertension, diabetes, prior stroke, female gender, carotid disease, peripheral vascular disease, and aortic atheroma.[2,3]

Perioperative neurologic injury associated with cardiac surgery is most commonly due to thromboembolic events (63-76%), the majority which do not occur in the frontal lobe.[4,5,6,7,8] Subclinical cerebral ischemia can be detected by magnetic resonance imaging in as many as 62% of high-risk patients, however, clinically detectable hypoperfusion related injury occurs in less than 5% of general autopsy cases, and up to 20-40% of cardiac surgical injuries, a large percent of which occurs in the frontal lobe.[2,3,4,5,6,8,9] These latter patients would be presumed to be detectable with rSO2/NIRS if they all occurred in the frontal lobe. Interestingly, 40-50% of new perioperative microbleeds occur in the frontal lobe, however, neuropsychiatric dysfunction in the postoperative period were unrelated, questioning the value of monitoring 2 cm of the frontal lobe at all.[10]

Regional cerebral oximetry (rSO2) using near-infrared spectroscopy (NIRS) was introduced in 1977 to measure cerebral oxygenation.[11] Reported associations between low rSO2 levels and adverse outcome has pushed its way into the clinical realm as a 'routine' monitor.[9,12,13,14,15,16] A preop or baseline rSO2 < 50% was associated with a 71% incidence of postoperative neurocognitive (delirium) dysfunction compared to 18% for those with rSO2 > 50%.[12,14,15] It's widespread adoption as a monitor of brain perfusion and to detect brain ischemia now includes treatment algorithms.[13,17,18] The association of abnormal values with outcome forced its way into clinical management without supporting evidence that it changes outcome and without have been compared to an accepted gold standard reference value. It is as though it has become the reference that dictates clinical care.

This rapid rise in use of rSO2 in line with that thinking that more data is better and is reminiscent of the quick adoption of the pulmonary artery catheter into clinical practice. In 1970 Swan and Ganz introduced a bedside evaluation of the right heart and pulmonary artery pressures using a 'balloon flotation flow-directed right heart catheter', which was followed by the Forrester Subsets reporting a greater mortality associated with an elevated pulmonary capillary wedge pressure and/or reduced cardiac output.[19,20,21,22] The pulmonary artery catheter was widely advocated and allowed to dictate care until 20-30 years later when practitioners were calling for a moratorium and writing its obituary.[10] Controversial or ongoing issues surrounding the routine use of the pulmonary artery catheter (PAC) were:

1. May not be accurate
2. Risks from catheter
3. Harm due to knowledge deficit
4. Data may not be useful
5. Data results in overtreatment

These same concerns exist with routine use of rSO2 monitoring used to monitor frontal cortex oxygen saturation, which is taken to be a proxy for whole brain perfusion.[9,16] Near-infrared light is emitted from pads placed on the forehead over the frontal lobe, it passes through the skull, into brain tissue where it is absorbed by oxygenated hemoglobin at a wavelength > 700nm. Non-absorbed radiation is reflected to the forehead sensors, where the intensity of reflected radiation is measured and used to calculate the ratio (rSO2) of oxygenated hemoglobin to total hemoglobin concentration, correcting for any superficial absorption by the forehead skin and anterior skull. Based on the assessment of < 2 cm of the frontal lobe, proponents claim that rSO2 reflects total brain perfusion and oxygenation. Unlike pulse oximetry, NIRS does not selectively target hemoglobin in the arterial vasculature, but instead is non-pulsatile disproportionately reflecting venous O2 hemoglobin saturation.[9,23] Therefore, rSO2 is more likely to represent a balance between O2 supply and demand.

Even if assumed that intraoperative assessment of 2 cm of frontal lobe oxygen saturation can detect hypoperfusion injury of the rest of the frontal lobe, the cause-and-effect relationship with postoperative morbidity and mortality, over the first week and beyond is not supported by the literature.[5,6,10,24,25,26,27] Skepticism is further supported that the fact that 50% neurologic injury occurs after waking up from anesthesia and due to a host of demographic and perioperative variables.[1,4,28,29] Given the unlikelihood that cerebral oximetry would help prevent perioperative neurologic injury, its use isn't included in perioperative prevention of neurologic injury.[4]

Is there an association between rSO2 and outcome? While a systematic review of multiple reports concludes that reductions in rSO2 'might' have an association with neurologic complications, statistically significant data connecting correction of reduced rSO2 with improved outcome are lacking.[1] The authors stating "...data are insufficient to conclude that interventions to improve rSco2 desaturation prevent stroke or POCD".[1] Although the occurrence of stroke was no different, declines in rSO2 of > 10-20% from baseline, or reductions to < 50% are considered significant and prompt therapies to improve cerebral oxygen balance to either increase oxygen delivery and/or reduce metabolism.[14,15] Based on the reported association between rSO2 and outcome, 'response protocols' to correct the cerebral desaturation have been proposed.[13,17,18]

1. Rule out arterial obstruction
2. Raise arterial pressure
3. Increase FiO2
4. Normalize or increase PaCO2
5. Optimize hemoglobin i.e., transfusion
6. Increase cardiac function i.e., fluids and inotropes
7. Decrease oxygen consumption by increasing anesthetic depth
8. Induce mild/moderate hypothermia

Murkin et al found that patients in the control group had a lower baseline and mean rSO2 during surgery, with more desaturation episodes.[17] The 30-day cumulative likelihood of a patient experiencing any one of many postoperative complications, including stroke, myocardial infarction (MI), re-exploration, death, or ventilation >48 hours was barely elevated in the control group (p=0.048),[17] and independently none of these outcomes were statistically significantly more likely in either group. It was not clarified how rSO2 desaturations were related to non-neurologic outcomes.[17]

Schoen et al failed to demonstrate any difference in the postoperative incidence of AKI, vasopressor requirement, or mechanical ventilation requirement for patients undergoing CABG and/or valve surgery, despite a significant difference in the incidence of rSO2 desaturation (<50%) episodes between their two study groups.[30] Similarly, Deschamps et al randomized 201 patients to cerebral saturation monitoring and an algorithm to pursue corrective actions after a 10% cerebral desaturation compared to baseline.[31,32] They found that cerebral desaturation occurred more commonly in the intervention group (70% vs 56%) and the cumulative time spent with a cerebral desaturation was greater in the control group than the intervention group (398±870mins vs 104±217mins). However, there was no difference found in any outcome data including time on mechanical ventilation, death, CVA and delirium among other adverse events studied.[31,32]

Even while more than 90% of reduced rSO2 can be 'corrected' to within 80% of baseline, there was no difference in outcome.[31,32] Subramanian et al reported that 61% of cardiac surgical patients experience at least 1 rSO2 desaturation and 340 in total.[18] Ten percent were unidentified, 34% resolved with 'usual' care, and 66% resolved with application of a treatment algorithm,[13,17] which included deepening anesthesia, instituting hypothermia, and increasing oxygen delivery by raising blood pressure, FiO2, PaCO2, and blood transfusion to greater than 7-8 gm/dl.[18] Despite correction of rSO2 in as many as 97%, neurologic outcomes did not improve.[33,34,35]

Guidelines to maintain systemic blood pressure are weakly or not at all supported by the literature.[4] Part of the confusion is a lack of consistent hemodynamic goal, highlighted by varying mean,[50,55,60] or 65mmHg....) and systolic pressure (85-90mmHg) thresholds, or percent changes (10-30%) from baseline.[4] Although proposed algorithms to correct cerebral desaturations include raising systemic blood pressure, Holmgaard et al reported that a higher mean blood pressure (67 vs 45 mmHg) during cardiopulmonary bypass was associated with lower absolute rSO2 and more frequent desaturations.[36]

While a link between cardiac surgery and post-operative neurocognitive dysfunction (POCD/NCD) is well-established, any link between cerebral desaturation and postoperative POCD/NCD is less certain.[2,3,37] Drawing from their systematic review of 43 articles, including 27 observational studies, Zheng et al suggest that findings and methodologies from articles published prior to February 2012 were too inconsistent to support a definitive association between intraoperative rSO2 reduction and postoperative complications such as stroke, POCD, and/or delirium.[1] A more recent systematic review and meta-analysis by Wong et al concluded that reported benefits of rSO2 monitoring during both cardiac and noncardiac surgical procedures, were graded as low-quality evidence due to high risk of bias, methodologic inconsistencies and publication bias.[38] In five randomized trials, including more than 1000 patients, in which evidence was graded as 'high' quality, there was no significant association between rSO2 and the incidence of postoperative delirium or stroke (38). Taken together, this suggests that the utility of cerebral oximetry alone to predict POCD, be it following cardiac or noncardiac surgery, is limited.[1,38]

A limitation of the literature are inconsistencies across studies making them difficult to compare. A normal rSO2 ranges from 60-80% but may be as low as 55%.[14,39] There is a wide range of how 'desaturation' is defined including absolute reductions below 50 or 55% and/or relative reductions of 10,20, or 25% from baseline, for varying durations.[40,41,42] Demographic differences in oximetry values are reported based on skin color and gender.[43] Measurement errors as high 15%

with anemia, and up to 30% with thicker skulls.[9] Reduced rSO2 could also reflect cerebral venous congestion, tissue edema, interference with by cerebral bleeds, and outside light.[9,23] Another limitation of rSO2 is manufacture differences each with their own algorithms to determine measurement distance and saturations.[40] While this doesn't necessarily negate the value of cerebral oximetry, it does emphasize the need to establish a baseline and not let care be dictated by oximetry.

Comparisons between rSO2/NIRS and accepted reference data are lacking. When compared to electroencephalogram during carotid surgery specificity and sensitivity of rSO2 are as low as 12-20%.[9] Stilo et al reported moderate sensitivity (60%) and low specificity (25%) for cerebral oximetry.[44] Although Mauermann et al reported higher sensitivities and specificities of 75% and 74% respectively, the authors note that rSO2 would have increased placement of a shunt by 20%.[45] The reported predictive positive value was < 21%.[45] In pediatric cardiac/congenital patients undergoing the Norwood procedure, cerebral oximetry was compared to cerebral venous oxygen saturation.[46] Overall, cerebral oximetry compared poorly especially with lower cerebral venous oxygen saturation. The authors concluded that 'Cerebral rSO2 in isolation should not be used to detect low ScvO2..... Cerebral rSO2 of 50 or greater should not be considered reassuring....'[46]

While routine use of rSO2 is not supported, there are specific case types where rSO2 may be useful. For major aortic cases in which aortic cannulae may require manipulation rSO2 may be helpful in assessing large changes in right and left cerebral perfusion.[9,14,16,39] The use of oximetry to assess renal and liver function has been described.[9,16,39] However, the uncertainty regarding routine application of and intervention based on NIRS cerebral oximetry data has led to the assertion by the Perioperative Quality Initiative on the role of neuromonitoring that "there is insufficient evidence to recommend using intraoperative cerebral oximetry to reduce mortality or organ-specific morbidity after cardiac surgery".[47] The authors also point out that until high quality evidence shows that treatment algorithms for decreased rcSO2 events improves outcomes, both the potential for overdiagnosis and cost-benefit analysis must be considered. Is rcSO2 a benign monitor? No. Not if it prompts therapies without clear evidence that such actions improve outcome.

References

1. Zheng F, Sheinberg R, Yee MS et al: Cerebral near-infrared spectroscopy monitoring and neurologic outcomes in adult cardiac surgery patients: a systematic review. *Anesth Analg.* 2013;116(3):663-676. doi:10.1213/ANE.0b013e318277a255
2. Gottesman RF, McKhann GM, Hogue CW: Neurological complications of cardiac surgery. *Semin Neurol.* 2008;28(5):703-715. doi:10.1055/s-0028-1105973
3. Gottesman RF, Sherman PM, Grega MA et al: Watershed stroke after cardiac surgery. Diagnosis, etiology, and outcome. *Stroke* 2006;37:2306-2311. DOI: 10.1161/01.STR.0000236024.68020.3a
4 Benesch C, Glance L, Derdeyn C et al: Perioperative Neurological Evaluation and Management to Lower the Risk of Acute Stroke in Patients Undergoing Noncardiac, Nonneurological Surgery A Scientific Statement From the American Heart Association/American Stroke Association. *Circulation* 2021;143:e923-e946. DOI: 10.1161/CIR.0000000000000968
5. Ko S-B: Perioperative stroke: pathophysiology and management. *Korean J Anesth* 2018;7:3-11. https://doi.org/10.4097/kjae.2018.71.1.3
6. Ng JL, Chan MTV, Gelb AW: Perioperative stroke in noncardiac, nonneurologic surgery. *Anesthesiology* 2011;115:879-890.

7. Top JM, Garcia E, Jara A et al: Incidence and etiological mechanism of stroke in cardiac surgery. *Neurology* 2020 Sept; 35(7): 458-63.
8. Pierik R, Uyttenboogaart M, Erasmus ME, Scheeren TWL, van den Bergh WM: Distribution of perioperative stroke in cardiac surgery. *Eur J Neurol.* 2018 Aug;26(1):184-90.
9. Murkin JM, Arango M: Near-infrared spectroscopy as an index of brain and tissue oxygenation. *Br J Anaesth.* 2009;103 Suppl 1:i3-i13. doi:10.1093/bja/aep299
10. Patel N, Banahan C, Janus J et al: Perioperative cerebral microbleeds after adult cardiac surgery. *Stroke* 2019;50:336-343. DOI: 10.1161/STROKEAHA.118.023355.)
11. Jobsis FF: Noninvasive, infrared monitoring of cerebral and myocardial oxygen sufficiency and circulatory parameters. *Science* 1977;198:1264-1267.
12. Heringlake M, Garbers C, Ka¨bler J-H et al: Preoperative cerebral oxygen saturation and clinical outcomes in cardiac surgery. *Anesthesiology 2011;* 114:58–69
13. Denault A, Deschamps A, Murkin JM: A proposed algorithm for the intraoperative use of cerebral near-infrared spectroscopy. *Seminars in Cardiothorac Vasc Anesth* 2007;11:274-281.
14. Vretzakis G, Georgopoulou S, Stamoulis K et al: Cerebral oximetry in cardiac surgery. *J Thorac Dis* 2014;6:S60-S69.
15. Lei CM, Katznelson R, Fedorko L et al: Cerebral oximetry and postoperative delirium after cardiac surgery: a randomised controlled trial. *Anesthesia* 2017:72:1456-1466.
16. Steppan J, Hogue CW: Cerebral and tissue oximetry. *Best Pract Res Clin Anaesth* 2014;28429-439. http://dx.doi.org/10.1016/j.bpa.2014.09.002
17. Murkin JM, Adams SJ, Novick RJ, et al. Monitoring brain oxygen saturation during coronary bypass surgery: a randomized, prospective study. *Anesthesia and Analgesia* 2007; 104:51–58.
18. Subramanian B, Nyman C, Fritock M et al: A Multicenter Pilot Study Assessing Regional Cerebral Oxygen Desaturation Frequency During Cardiopulmonary Bypass and Responsiveness to an Intervention Algorithm. *Anesth Analg* 2016;122:1786-1793.
19. Forrester JS, Diamond G, Chatterjee K, Swan HJC: Medical therapy of acute myocardial infarction by application of hemodynamic subsets (part I). *N Engl J Med.* 1976;295:1356 –1362.
20. Forrester JS, Diamond G, Chatterjee K, Swan HJC: Medical therapy of acute myocardial infarction by application of hemodynamic subsets (part II). *N Engl J Med.* 1976;295:1404 –1413.
21. Chatterjee K: The Swan-Ganz catheters: Past, present, and future. *A viewpoint. Circulation* 2009;119:147-1152.
22. Marik PE: Obituary: pulmonary artery catheter 1970 to 2013. *Annals of Inten Care* 2013;3:38. http://www.annalsofintensivecare.com/content/3/1/38
23. Butler E, Chin M, Aneman A: Peripheral Near-Infrared Spectroscopy: Methodologic Aspects and a Systematic Review in Post-Cardiac Surgical Patients. *J Cardiothorac Vasc Anesth.* 2017;31(4):1407-1416. doi:10.1053/j.jvca.2016.07.035
24. Mangla R, Kolar B, Almast J, Ekholm SE: Border zone infarcts: Pathophysiologic and imaging characteristics. *RadioGraphics* 2011;31:1201-1214. 10.1148/rg.315105014

25. Momjian-Mayor I, Baron J-C: The pathophysiology of watershed infarction in internal carotid artery disease. Review of cerebral perfusion studies. *Stroke* 2005;36:567-577. DOI: 10.1161/01.STR.0000155727.82242.e1

26. Zorrilla-Vaca A, Grant MC, Joshi B et al: Intraoperative cerebral oximetry-based management for optimizing perioperative outcomes: a meta-analysis of randomized controlled trials. *Can J Anaesth* 201865:529-542

27 Colak Z, Borojevic M, Bogovic A et al: Influence of intraoperative cerebral oximetry monitoring on neurocognitive function after coronary artery bypass surgery: a randomized, prospective study. *Europ J Cardiothorac Surg* 2015;47:447-454.

28 Tosh W, Patteril M: Cerebral oximetry. *BJA Education.* 2016;16:417-421. doi: 10.1093/bjaed/mkw024

29 Gaudino M, Rahouma M, Di Mauro M et al: Early Versus Delayed Stroke After Cardiac Surgery: A Systematic Review and Meta-Analysis. *J Am Heart Association* 2019;8(13):e012447. doi:10.1161/JAHA.119.012447

30. Schoen J, Husemann L, Tiemeyer C, et al: Cognitive function after sevoflurane- vs propofol-based anaesthesia for on-pump cardiac surgery: a randomized controlled trial. *Br J Anaesth.* 2011;106(6):840-850. doi:10.1093/bja/aer091

31. Deschamps A, Hall R, Grocott H, Mazer CD et al for The Canadian Anesthesia Clinical Trials Group: Cerebral oximetry monitoring to maintain normal cerebral oxygen saturation during high-risk cardiac surgery. *Anesthesiology*2016; 124:826-836. doi:10.1097/ALN.0000000000001029

32. Deschamps A, Lambert J, Couture P et al: Reversal of decreases in cerebral saturation in high-risk cardiac surgery. *J Cardiothoracic Vasc Anesth* 2013;27:1260-1266.

33. Serraino GF, Murphy GJ: Effects of cerebral near-infrared spectroscopy on the outcome of patients undergoing cardiac surgery: a systematic review of randomised trials. *Brit Med J.* 2017;7: e016613. doi:10.1136/bmjopen-2017-016613

34. Green DW, Kunst G: Cerebral oximetry and its role in adult cardiac, non-cardiac surgery and resuscitation from cardia arrest. *Anaesthesia* 2017;72:48-57

35. Slater JP, Guarino T, Stack J, et al. Cerebral oxygen desaturation predicts cognitive decline and longer hospital stay after cardiac surgery. *Annals of Thoracic Surgery* 2009; 87: 36–44

36 Holmgaard F, Vedel AG, Lange T, Nilsson JC, Ravn HB: Impact of 2 Distinct Levels of Mean Arterial Pressure on Near-Infrared Spectroscopy During Cardiac Surgery: Secondary Outcome From a Randomized Clinical Trial. *Anesth Analg* 2019;128:1081-1088.

37. Berger M, Terrando N, Smith SK et al: Neurocognitive Function after Cardiac Surgery: From Phenotypes to Mechanisms. *Anesthesiology.* 2018;129(4): 829-851. doi:10.1097/ALN.0000000000002194

38. Wong ZZ, Chiong XH, Chaw SH, et al: The Use of Cerebral Oximetry in Surgery: A Systematic Review and Meta-analysis of Randomized Controlled Trials, *J Cardiothoracic and Vascular Anesthesia* (2021), doi:https://doi.org/10.1053/j.jvca.2021.09.046

39. Tosh W, Patteril M: Cerebral oximetry. *BJA Education.* 2016;16:417-421. doi: 10.1093/bjaed/mkw024

40 Lim L, Nam K, Lee S et al: The relationship between intraoperative cerebral oximetry and postoperative delirium in patients undergoing off-pump coronary artery bypass graft surgery: a retrospective study. *BMC Anesthesiology.* (2020) 20:285 https://doi.org/10.1186/s12871-020-01180-x

41. Yu Y, Liu Y, Meng L, Han R: Monitoring cerebral ischemia using cerebral oximetry: pros and cons. *J Biomedical Res* 2016;30:1-4. doi: 10.7555/JBR.30.20150096

42. Gregory A, Kohl BA: Con: Near-infrared spectroscopy has not proven its clinical utility as a standard monitor in cardiac surgery. *J Cardiothoracic Vasc Anesthesia* 2013;27:390-394.

43. Bickler PE, Feiner JR, Rollins RD: Factors Affecting the Performance of 5 Cerebral Oximeters During Hypoxia in Healthy Volunteers. *Anesth Analg* 2013;117:813-823. DOI: 10.1213/ANE.0b013e318297d763

44. Stilo F, Spinelli F, Martelli E, et al. The sensibility and specificity of cerebral oximetry, measured by INVOS-4100, in patients undergoing carotid endarterectomy compared with awake testing[J]. *Minerva Anestesiol* 2012,78(10):1126-1135.

45. Mauermann WJ, Crepeau AZ, Pulido JN et al: Comparison of electroencephalography and cerebral oximetry to determine the need for in-line arterial shunting in patients undergoing carotid endarterectomy. *J Cardiothoracic Vasc Anesth* 2013;27:1253-1259.

46. Rescoe E, Tang X, Perry DA et al. Cerebral near infrared spectroscopy insensitively detects low cerebral venous oxygen saturations after stage 1 palliation. *J Thorac Cardiovasc Surg.* 2017;154:1056-62.

47. Thiele RH, Shaw AD, Bartels K et al; Perioperative Quality Initiative (POQI) 6 Workgroup. American Society for Enhanced Recovery and Perioperative Quality Initiative Joint Consensus Statement on the Role of Neuromonitoring in Perioperative Outcomes: Cerebral Near-Infrared Spectroscopy. *Anesth Analg.* 2020 Nov;131(5):1444-1455. doi: 10.1213/ANE.0000000000005081. P MID: 33079868.