SCA NEWS

OCTOBER 2021

SOCIETY OF CARDIOVASCULAR ANESTHESIOLOGISTS
Knowledge • Care • Investigation

President's Message

Andrew Shaw
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President, Society of Cardiovascular Anesthesiologists

Introducing the Monthly Clinical Updates Initiative

As learning continues to evolve, the SCA continues to align its efforts with the needs of its members. The Online Education Subcommittee initially focused on creating the infrastructure that would allow the SCA to launch a robust longitudinal educational program. The SCA understand that members desire to focus their efforts and fill their own specific gaps. Online education allows high quality opportunities for professional development throughout the year.

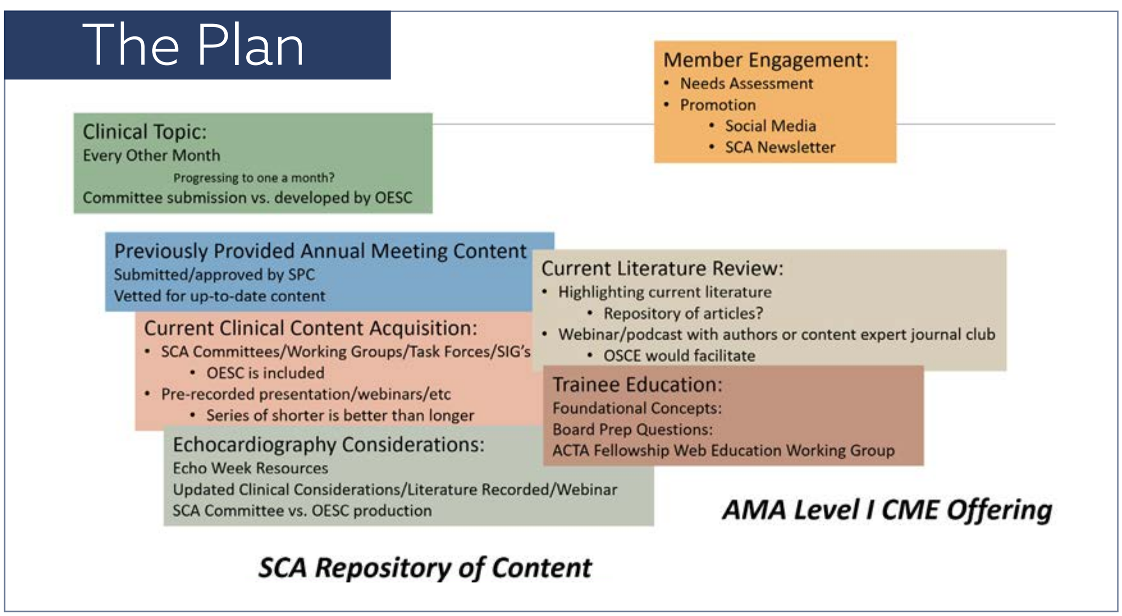
The Online Education Subcommittee is thrilled to announce the release of the monthly clinical updates initiative. Utilizing the content experts provided by the various committees and task force within the SCA, online content will be developed and available for SCA members to access. These longitudinal learning opportunities will be topical and multi-layered (See below). Not all topics will contain all suggested layers, but it is the long-term goal to continue developing each area.

The month of October will be focused on Extracorporeal Membrane Oxygenation with updated content provided by the SCA's ECMO Task Force. November's focus will shift towards thoracic anesthesia, with the Thoracic Anesthesia Symposium team leading the content development. Future topics are still being developed by will follow the content outlined by Kaplan's Cardiac Anesthesia.

This exciting endeavor will be accessible on the SCA's webpage. Watch for announcements and take this opportunity to engage!

Regards,

Andrew Shaw



Registration opens in November!

Join Us for the 2022 PoCUS Hands-On Workshop

We hope to see you on February 17, 2022, in Atlanta, GA, for the upcoming Perioperative Ultrasound Course: Hands-On Workshop!

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.

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.

Keep an eye out — **registration opens in November!**

Check out the PoCUS website page for more information on the course.

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ECHO WEEK

Save the Date for this exciting conference!

2022 Echo Week — Registration Opening Soon

February will be here before you know it, which means it's almost time to register for the 2022 Echo Week! Join us February 18-20, 2022 in Atlanta, Georgia.

This three-day conference will feature multidisciplinary panels on the role of echocardiography in surgical decision making in valvular disease and mechanical circulatory support, clinical dilemmas uniquely encountered in the operating room that may alter the surgical plan, and structural heart disease transcatheter procedures.

There will be several in-person only, deep-dive sessions on acquisition and postprocessing using advanced echocardiographic techniques (3D echocardiography and strain), congenital disease using 3D heart models, and heart dissections geared towards a better understanding of echo-anatomic correlation in transcatheter procedures and surgical interventions.

Registrants will also have access to our on-demand Echo Core Series, several lectures focused on reviewing fundamental echocardiographic concepts in physics, valvular disease, ventricular function evaluation, mechanical circulatory support, and transcatheter procedures.

Registration opens in November.

Visit Echo Week to view more meeting details.

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TAS 2022

THORACIC ANESTHESIA SYMPOSIUM

10th Anniversary Thoracic Anesthesia Symposium

Join Us in Palm Springs, Calfornia!

Please join us in sunny California for a day of lectures, workshops, and mentoring through both PBLDs and resident/fellow sessions.

A town hall discussion on anything you may want to explore or share with our panel of experts or with your colleagues and be sure to support and encourage our fellows and residents at the abstract/poster stations and during the "best case" and "best research" sessions.

The TAS Planning Committee is looking forward to seeing you in sunny Palm Springs, CA, for the 10th Anniversary Thoracic Anesthesia Symposium.

Registration opens in November. Visit TAS2022 to view more meeting details.

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OPENS IN NOVEMBER

Mark Your Calendar

Join your fellow members in Palm Springs, CA on 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.

Learn from abstract presentations, the popular Super Echo Panel and legendary Echo Jeopardy, and special session from the experts on the new Cardiothoracic Anesthesiology Certification exam.

Don't miss out on coming together in 2022 for this fantastic meeting!

Registration opens in November. Visit Annual Meeting 2022 to view more meeting details.

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SCA 2022

Call for Submissions

The Society of Cardiovascular Anesthesiologists (SCA) invites you to submit an abstract or challenging case for presentation at the 2022 Annual Meeting & Workshops and Annual Thoracic Anesthesia Symposium in Palm Springs, CA.

SUBMISSIONS WILL BE ACCEPTED IN THE FOLLOWING CATEGORIES:

Annual Meeting and Workshops

- Scientific Program
- Resident & Fellow Complex Case
- Super Echo

Thoracic Anesthesia Symposium

- Basic and Clinical Research
- Difficult Case
- Resident & Fellow Submission

CALL OPENS: November 1, 2021 • CALL CLOSES: December 10, 2021

Visit www.scahq.org to view the call for submission guidelines and start your online submission.

Questions? Contact **education@scahq.org.**

Submit a Challenging Case or Abstract

Early Career Investigator Award

The Research Committee will select the top five eligible abstracts to receive an SCA Early Career Investigator Award. Each recipient will be recognized during the SCA Annual Meeting and in the SCA Newsletter, give an oral presentation of the abstract during the Annual Meeting, and receive a $1,000 travel award to allow attendance at the Annual Meeting. The single best abstract will be identified by announcement of the prize winner at the Annual Meeting.

Priority will be given to studies that elucidate the pathophysiology of cardiac, thoracic, or vascular disease or explore novel therapeutic possibilities based on mechanisms of disease.

For general rules, eligibility and application requirements, please visit [Early Career Investigator Award](#).

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Research Funding Opportunities Available

The 2022 Research Grant applications opens in October.

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 during the SCA 2022 Annual Meeting & Workshops. The grant period of 24 months can begin any time from July 1 to December 31 of the year granted.

Applications will close in **January 2022.** More information about these funding opportunities will be posted on the SCA website.

The Kaplan Leadership Development Award

The 2022 Kaplan Leadership Development Award application submission opens in December. 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 award granted is $10,000: $5,000 from the SCA Endowment with $5,000 matched from the applicant's institution to fund a leadership education strategy.

Check out **Kaplan Award** for more information on this award and how to apply.

LEARN MORE ONLINE

Have You Been Thinking of Starting a Research Project?

The SCA is pleased to announce that it will begin funding up to four Participant User File (PUF) Research Grant Proposals each year!

A "Call for PUF Research Grant Proposals" will open in early 2022. Each selected applicant will be awarded up to $15,000 to apply for and complete an STS Participant User file (PUF) Grant.

More information on how to apply will be available in the coming weeks!

Requirements for proposed research projects are available at **https://www.sts.org/research-center/programs-and-data-access/participant-user-file-research-program**.

Find more information on the use of the Adult Cardiac Section of the STS Adult Cardiac Surgery Database at **https://www.jcvaonline.com/article/S1053-0770(20)30798-9/pdf.**

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SCA NEWS

The SCA DocMatter Community Coming Soon as a New Member Benefit

As a new benefit of SCA membership, you wil have access to the new SCA DocMatter Community — a global medical platform for high-quality, moderate and organized, clinical and research-based discussions among SCA members.

This secure, private community is an online representation of the collaborative, networking environment of SCA in-person meetings and allows for open, in-depth discussions between members, from questions on cases, the latest research and products, best practices, and more!

SCA members will be able to connect with your peers easier and more efficiently than ever before — you will be paired with a DocMatter Clinician Advocate to provide technical support as well as personalize your notifications, settings, and overall experience of the community based on your specific clinical interests.

In the SCA DocMatter Community, you can turn any video, piece of literature, or other one-way digital educational media into a meeting session, complete with ongoing Q&A, so member interactions do not have to be limited to a couple of times a year!

Watch your email for an invitation to join SCA DocMatter Community. We look forward to you experiencing our new forum.

Donate to the SCA Endowment today

Building the SCA Future Together Through the SCA Endowment

SCA is the preeminent international educational organization for this sub-specialty, leading the way in treatment innovations through care, investigation, and knowledge. By donating to the SCA Endowment, the funds help support SCA professionals to further their education, research, and professional development and to achieve their goals.

The SCA Endowment Fund online donation page is available. Making an online donation is quick, easy, and secure. To complete the online donation form, visit **www.scahq.org/Endowment.**

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

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MEMBER CORNER

SCA Social Media App — Download it NOW!

The SCA Social Media App is available on the Apple and Android app store for FREE!

SCA has released an official app that gives you easy access to everything SCA offers, including:

- SCA Guidelines
- Timely Webinars
- Educational Content
- Social Media Channels
- The SCA Website

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Stay connected with SCA

Be in the Know: Like, Share, Tweet and Follow

All it takes is a like, share, tweet, and a follow! Stay up to date on all things SCA by following us on social media! Connect with SCA and fellow members by liking us on Facebook **@Society of Cardiovascular Anesthesiologists** and following us on twitter **@scahq** and Instagram **@sca.hq**.

Tag us in your posts and make sure to use the SCA hashtags for all upcoming webinars and meetings!

Post a Job and Build a Diverse Team

Take the next step in building your dream team. SCA Career Center is the source to hire top cardiovascular anesthesiologists team members. With a membership of 4,000 professional members, the SCA Career Center is the first place employers look to build their team. Put your job opening in front of the largest network of highly skilled cardiovascular anesthesiology professionals at all levels.

Get started now — new team members are just a few clicks away!
Visit **SCA Career Center** for more details and to get started on your search.

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THORACIC CORNER

International Consensus Recommendations for Anesthetic and Intensive Care Management of Lung Transplantation. An EACTAIC, SCA, ISHLT, ESOT, ESTS, and AST Approved Document

Marczin N, De Waal EEC, Hopkins PMA, et al. J Heart Lung Transplant. Article in Press. (2021): S1053-2498(21)02414-1.

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Ashley Virginia Fritz, DO[1], Archer Kilbourne Martin, MD[1]

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Background

Lung transplantation is an international multidisciplinary subspecialty that necessitates common knowledge, communication, and goals across various stakeholders to achieve optimal outcomes.[1] Due to the lack of consensus guidelines within anesthetic practice, and in an effort to increase knowledge of intra-specialty practice differences, recent efforts within the literature have sought to obtain an understanding of the diversity of lung transplantation practices through international surveys.[2] Led and coordinated by Dr. Nandor Marczin of Imperial College London, these consensus recommendations represent the first effort in providing the common knowledge of best known practices across international boundaries within the subspecialty of lung transplantation anesthesiology.[3] Beginning with the European Association of Cardiothoracic Anaethestists (EACTA) Transplant Subcommittee, the collaboration extended into multidisciplinary transplant organizations across the globe. The aim of this current manuscript is to not only develop a common knowledge amongst the international anesthetic community of best practices in lung transplantation, but to set the foundation for a collaborative framework of continuous assessment of the impact of perioperative management on lung transplantation outcomes.[4]

Methods

The authors' first goal was to achieve an extensive network of experts to provide input into the consensus document. Beginning with the EACTA Transplant Subcommittee, invitations were expanded throughout the EACTA Subcommittee leadership structure to achieve a well-rounded evaluation of the entire perioperative lung transplantation process. Soon thereafter, international societies, such as the Society of Cardiovascular Anesthesiologists (SCA) and International Society for Heart and Lung Transplantation (ISHLT) were engaged to provide further collaborative structure.

In all, a panel of over 80 international experts from 50 lung transplantation centers were identified from the following sub-specialties: anesthesiology, intensive care medicine, transplant surgery, transplant pulmonology, pharmacology, and nursing.[3] These experts were then sub-divided into task force subgroups, and assigned various aspects of perioperative management. After initial task force discussions, preliminary findings were shared for feedback at several EACTA congresses. Subsequently, anonymous online survey tools were used to assess expert recommendation scoring, with written feedback required for any recommendation that received a significantly negative score from any individual reviewer. Once ranked, recommendations were compiled, shared with collaborating societies for review from both guidelines' committees and general membership, and feedback from this process was further incorporated into the final recommendation structure.

Results

The vast majority of recommendations received "strong consensus", receiving at least an 80% consensus among the experts, with the lowest scoring recommendation of 70% resulting in an "agreed consensus" strength. The recommendations were categorized into various perioperative sections (Table 1), and the respective sections were also expanded upon by the team in supplemental papers attached to the executive summary.

TABLE 1
Perioperative sections within Consensus Document[3]

Pre-operative evaluation for lung transplantation
Perioperative monitoring during lung transplantation
General intraoperative management in lung transplantation
Management of pulmonary hypertension in lung transplantation
Hemostasis management during lung transplantation
The role of transesophageal echocardiography during lung transplantation
Intensive care management in lung transplantation
Mechanical respiratory and circulatory support during lung transplantation
Pain management for lung transplantation
Surgical complications

Discussion

The tremendous effort undertaken by Dr. Marczin and his colleagues is significant for several reasons. First, it is the only document to date that has developed a common expert knowledge of the entire perioperative management of lung transplantation. The design of this project is rooted in a multidisciplinary, international, and collaborative worldview, further strengthening the quality of the consensus recommendations given.

Second, this consensus document not only sought to define knowledge, but to re-define goals of anesthesiologists as well. Within the introduction of this document is a section describing the "paradigm change"[3] advocated by the group, and it is one of integrated perioperative care within the lung transplantation process. Focus on amelioration of primary graft dysfunction (PGD) is described, and while this has been previously described in the literature[4], the consensus document solidifies the concept into a framework for future investigation.

Third, this document defines a methodology for communication across international centers within the clinical, educational, and research aspects of lung transplantation anesthesiology. The utilization of online tools in combination with multi-societal collaboration will serve as an example for facilitating further projects within this field.

The history of lung transplantation has been marked by ever increasing collaboration across multiple specialties and international centers. Over time, progressive advancements have been derived from these relationships, and ISHLT Registry data have shown improved outcomes in each successive decade. To continue the advancement of outcomes in these complex patients, multidisciplinary teams will need to share knowledge, goals, and avenues of communication across international lines. This consensus document provides us with outstanding achievements in those areas and serves as an example for future investigators to follow.

References

1. Martin AK, Fritz AV, Ramakrisha H. Multidisciplinary collaboration: the key to advancing lung transplantation outcomes. *Indian Journal of Thoracic and Cardiovascular Surgery.* (2021). https://doi.org/10/1007/s12055-021-01182-5
2. Tomasi R, Betz D, Schlager S et al. Intraoperative Anesthetic Management of Lung Transplantation: Center-Specific Practices and Geographic and Centers Size Differences. *J Cardiothorac Vasc Anesth.* 2018 Feb;32(1):62-69.
3. Marczin N, De Waal EEC, Hopkins PMA, et al. *J Heart Lung Transplant.* Article in Press. (2021): S1053-2498(21)02414-1.
4. Martin AK, Yalamuri SM, Wilkey BJ, et al. The Impact of Anesthetic Management on Perioperative Outcomes in Lung Transplantation. *J Cardiothorac Vasc Anesth.* 2020;34(6):1669-1680.

Perioperative Dexmedetomidine and 5-year Survival in Patients Undergoing Cardiac Surgery

Ke Peng, Yue-ping Shen, Yao-yu Ying, Bob Kiaii[4] Victor Rodriguez, Douglas Boyd, Richard L. Applegate II , David A. Lubarsky, Zugui Zhang, Zhengyuan Xia, Xiao-mei Feng, Jian-ping Yang, Hong Liu and Fu-hai Ji.
Perioperative Dexmedetomidine and 5-year Survival in Patients Undergoing Cardiac Surgery. *Br J Anaesth* 2021; 127: 215-23.

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Background

Cardiac surgical procedures utilizing cardiopulmonary bypass (CPB), such as coronary artery bypass grafting (CABG) or valve replacement, carry significant risk of both morbidity and mortality. As such, there is great interest in the application of strategies that may mitigate these risks. Dexmedetomidine is a selective +2-adrenergic agonist with analgesic, sedative, anti-inflammatory and sympatholytic effects.[1] It is utilized in operating room and critical care settings primarily to provide sedation. In animal models, dexmedetomidine, via its anti-inflammatory properties has been demonstrated to decrease cytokine concentrations and reduce mortality in the setting of endotoxin exposure.[2] In humans, dexmedetomidine has been shown to reduce inflammatory mediators in patients undergoing CPB3 furthering interest in the potential for reduction of adverse events in this patient population. Previous studies revealed improved 1-year survival and morbidity in cardiac surgical patients who received dexmedetomidine compared to those who did not.[4,5] Furthering this investigative effort, in this study Peng et al[6], examine the association between intraoperative administration of dexmedetomidine and long-term mortality in patients having undergone certain cardiac surgical interventions with CPB when compared with patients that did not receive dexmedetomidine.

Methods

This is a retrospective, single-center, cohort study of 2452 consecutive patients who underwent cardiac surgery at the University of California, Davis Medical Center from January 1, 2004 to April 30, 2014. Included were patients having on-pump CABG, valve replacement or combined procedures. Exclusion criteria included emergency surgery, off-pump or robotic assisted surgery, or thoracic aortic surgery. Of the participants, 1029 received a dexmedetomidine infusion (DEX) while 1039 did not (non-DEX). The decision to begin an infusion or not, as well as the titration of the medication was at the discretion of the attending anesthesiologist. The IV dexmedetomidine infusion of 0.007 mcg/kg/min (without a loading dose; or 0.42mcg/kg/h) prior to the initiation of CPB and continued until extubation or terminated within 24 hours if the patient remained intubated. Data extraction was conducted independently by two authors from the medical record and the institutional Society of Thoracic Surgery (STS) database using parameters such as medical history, preoperative medications, procedural characteristics and clinical outcomes.

The primary outcome measured was 5-year mortality although mortality was reported as 30-day, 1,2,3,4 and 5 years postoperatively. Secondary outcomes included any included early postoperative issues of: myocardial infarction, heart block, cardiac arrest, stroke, coma, pulmonary complications, GI complications, end organ damage, 30-day readmission and length of stay based on outcomes reported in the STS database.

To adjust for between-group differences the authors utilized three different adjustment methods based on propensity scoring: Inverse probability treatment weighting (IPTW), overlap weighting and propensity score matching (PSM).

Results

T452 patients were screening for inclusion of which 2068 were enrolled with 1029 having received dexmedetomidine infusion and 1039 patients that did not receive dexmedetomidine. While the groups had similar patient and medical history characteristics, there were significant differences in procedural characteristics, including (surgeon, surgical procedure, surgical urgency, pre-operative medications, bypass time, ejection fraction, cross-clamp time amongst others) To account for these differences the authors employed sophisticated matching techniques (IPTW, overlap weighting, and PSM). Following matching, the authors had 415 patients that received dexmedetomidine and 415 that did not receive.

The mortality outcomes were reported for the unadjusted and matched groups at 30 days and early for 5 years following surgery. At 5 years the odds ratio of the unadjusted group was (OR=0.60; 95% CI, 0.47-0.76; P<0.001) and for the matched group (OR=0.61; 95% CI, 0.42-0.89; P<0.01).

Examining secondary outcomes in the matched cohort, the authors found differences in a number of outcomes of delirium, sepsis, reintubation and reoperation were the only outcomes maintaining statistical significance between the groups.

Discussion

Previous retrospective studies in the cardiac surgical population have suggested a benefit from dexmedetomidine infusion on postoperative survival[4,5,7] and morbidity.[5,7] These studies have reported outcomes up to one year postoperatively but there is a paucity of evidence demonstrating improvement in longer term outcomes with dexmedetomidine in cardiac surgery. The authors of this study are the first to have undertaken the difficult task of examining the outcomes of dexmedetomidine use in cardiac surgery up to 5 years postoperatively. Using advanced statistical techniques to balance groups they demonstrated that the DEX group had significantly improved outcomes as compared to the non-DEX group.

While these results are certainly intriguing, they must be interpreted cautiously. While retrospective studies use matching to adjust for differences in characteristics and demographics, it is not possible to adjust for factors including the providers decision in their conduct of the anesthetic. Moreover, given the immense number of both measurable and non-measurable variables that contribute to mortality, it becomes difficult to adjust for collinearity amongst these factors. Certainly, the non-DEX patient characteristic suggested a sicker population which may have influenced the choice of anesthetic. Conversely, it may represent the individualized practice of the anesthesiologist caring for the patient. Similarly, we note a significant shift towards dexmedetomidine use in the later 5 years of the cohort owing to changes in institutional practice rather than in response to patient severity of illness. As the authors point out, dexmedetomidine has properties that may alter the anesthetic delivered in terms of (but not limited to) intraoperative maintenance medications, postoperative sedation and opioid administration. This information was not included in the study and the implications of differences among these strategies would best be addressed prospectively.

Perhaps most importantly is the observation that the 2-year mortality for both the unadjusted and matched analysis groups failed to reach statistical significance. This would suggest that the observation of reduced mortality attributed to dexmedetomidine was not present at 2 years but returned in subsequent years. This is unlikely given that the intervention was use of dexmedetomidine only on the day of surgery. The authors are to be commended for their efforts in presenting such promising retrospective data on the long-term implications of perioperative dexmedetomidine use in cardiac surgery. While the conclusions should be interpreted with caution given the limitations of the study, this provides even more evidence that prospective trials on this topic are desperately needed.

References

1. Gerlach AT, Murphy CV, Dasta JF. An updated focused review of dexmedetomidine in adults. *Ann Pharmacother* 2009; 43: 2064-74.
2. Taniguchi T, Kurita A, Kobayashi K, et al. Dose- and time-related effects of dexmedetomidine on mortality and inflammatory responses to endotoxin-induced shock in rats. *J Anesth* 2008; 22:221-228.
3. Ueki M, Kawasaki T, Habe K, et al. The effects of dexmedetomidine on inflammatory mediators after cardiopulmonary bypass. *Anaesthesia* 2014; 69(7):693-700.
4. Ji F, Li Z, Young N, Moore P, Liu H. Perioperative dexmedetomidine improves mortality in patients undergoing coronary artery bypass surgery. *J Cardiothoracic Vasc Anesth* 2014; 28:267-73.
5. Ji F, Li Z, Nguyen H et al. Perioperative dexmedetomidine improves outcomes of cardiac surgery. *Circulation* 2013; 127: 1576-84.
6. Peng K, Shen Y, Ying Y, et al. Perioperative dexmedetomidine and 5-year survival in patients undergoing cardiac surgery. *Br J Anaesth* 2021; 127: 215-23.
7. Brandao PG, Lobo FR, Ramin SL, Sakr Y, Machado MN, Lobo SM. Dexmedetomidine as an anesthetic adjuvant in cardiac surgery: a cohort study. Braz *J Cardiovasc Surg* 2016; 31: 213e8.

Markers of Elevated Left Ventricular Filling Pressure are Associated with Increased Mortality in Nonsevere Aortic Stenosis

Giudicatti, L.C., Burrows, S., Playford, D., Strange, G., & Hillis, G. (2021). Markers of Elevated Left Ventricular Filling Pressure are Associated with Increased Mortality in Nonsevere Aortic Stenosis. *Journal of the American Society of Echocardiography: official publication of the American Society of Echocardiography,* 34(5), 465–471.

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Background

Aortic stenosis (AS) affects 4 to 5% of individuals over 65 years old. The severity of aortic stenosis can be graded based on the mean transvalvular pressure gradient (MPG) and aortic valve area (AVA), with severe AS defined as a MPG of ≥ 40 mmHg and AVA of ≤ 1.0 cm2 and moderate AS defined as a MPG of ≥ 10 and < 40 mmHg and AVA of 1.0 - 1.5 cm2.[1] The natural history and survival benefit of aortic valve intervention in surgically appropriate patients with severe AS has been thoroughly investigated in the literature with well supported recommendations for replacement in this population.[2] However, the same cannot be said regarding the characterization and survival of patients with moderate AS. As such, despite emerging evidence that patients with moderate AS have poor long-term survival, by present guidelines, most do not meet criteria for valve intervention.

Currently, the predominant echocardiographic predictors for survival that drive intervention timing are indices that reflect stenosis severity, left ventricular systolic function, and pulmonary hypertension.[3] This fails to consider the progressive diastolic disturbance that occurs in aortic stenosis as consequence of reduced myocardial compliance. In this study, the authors propose that diastolic indices reflecting acute and chronic elevations in left ventricular filling pressure (LVFP) may capture early hemodynamic consequences of AS and thus play a role in the prognostication of nonsevere (mild and moderate) AS patients. Their aim was to determine the relationship between these diastolic indices and mortality in patients with nonsevere AS.

Methods

The authors utilized the National Echo Database Australia (NEDA) data set to perform a retrospective cohort study of patients from April 11, 2000 to June 13, 2017. At the time of the study, there were over 500,000 echocardiography studies in the database from approximately 350,000 individuals. The inclusion criterion of the study was men and women age ≥ 18 years with at least 1 echocardiogram. Only one echocardiogram was used for each patient. Hemodynamically significant but nonsevere AS ("nonsevere AS") was defined as aortic valve MPG ≥10 and < 40 mmHg and AVA > 1 cm2. An echocardiographic control group of patients without hemodynamically significant AS ("no AS") was identified by aortic valve MPG < 10 mmHg and AVA > 1 cm2. Patients who had undergone aortic valve interventions were excluded from the study.

The authors defined acutely elevated LVFP as the ratio of early transmitral flow to mitral annular velocity (E/e') and chronically elevated LVFP as indexed left atrial volume (LAVI). Left ventricular ejection fraction (LVEF) was used as a surrogate echocardiographic marker for systolic function and maximum tricuspid regurgitation (TR) velocity was used as a surrogate echocardiographic marker for pulmonary hypertension. These features were studied as continuous and dichotomized variables, using the cutoff ranges of LAVI > 34 mL/m2, average E/e' > 14, LVEF ≥ 50%, and TR velocity of > 280 cm/s for the dichotomy analyses.

The primary outcome was mortality and Kaplan-Meier survival curves were used to demonstrate the differences between subgroups.

Results

The final study sample comprised 78,886 patients with 13,768 patients who met criteria for nonsevere AS. In comparing the nonsevere AS cohort to the no AS cohort, there was a statistically and clinically significant difference between the groups in many characteristics including gender (50.8% male [no AS] vs 57.2% male [nonsevere AS]) and age at echocardiography (60.8 years ± 17.8% [no AS] vs 73.7 years ± 13.4% [nonsevere AS]).

In regards to measured echocardiographic variables, there were statistically significant elevations in LVFP in the nonsevere AS group compared to the no AS group as indicated by LAVI (38.4 vs 32.4 mL/m2, respectfully) and E/e' ratio (13.2 vs 12.0, respectfully). There were also statistically significant increases in peak TR velocities (277 cm/s [nonsevere AS] vs 256 cm/s [no AS]). While statistically significant, there was not a clinically significant difference in LVEF between the two groups (62.5% [nonsevere AS] vs 60.0% [no AS]).

In investigating the primary endpoint of mortality in the context of continuous variables, there was an unadjusted two-fold increased risk of death in the nonsevere AS cohort (median survival of 14.8 years [nonsevere AS] vs8.7 years [no AS]). Although the mortality in the nonsevere AS group may be related to the older population, after age and sex adjustments, there was still a 7% increase in mortality in the nonsevere AS cohort.

When the dichotomized variables were studied in relation to mortality, there was a significantly increased hazard ratio in the patients with LAVI > 34 mL/m2, LVEF < 50%, TR peak velocity > 280 cm/s, and E/e' ratio > 14 with univariable analyses. With multivariable analysis, only peak TR velocity, LVEF, and LAVI remained statistically significant, and the ratio of E/e', an acute marker of LVFP, was no longer significant. However, when investigating the hazard ratio overtime, the E/e' ratio was demonstrated to increase over the follow up period and conferred a 5% risk of death every year after year 1 whereas the prognostic impact of LVEF and TR peak velocity decreased with time.

The authors also investigated the mortality risk when considering the cumulative echocardiographic markers of both systolic (LVEF, TR peak velocity) and diastolic function (LAVI, E/e' ratio) and found incrementally increased hazard ratios with each additional metric of echocardiographic dysfunction.

Discussion

The results of this study support the conclusion that measures of acutely and chronically elevated LVFP are independent predictors of all-cause mortality in nonsevere AS patients. As such, they may play an important role in the identification of patients with nonsevere AS with a worse long-term prognosis. In considering this phenomenon, the authors propose two mechanisms for this finding. First, that it may be due to the hemodynamic consequences of AS which include early left ventricular remodeling and diastolic dysfunction. Second, that decrease in myocardial compliance and subsequent increase in LVFP may represent a multifactorial end result originating from multiple pathophysiologic pathways including hypertension and age.

Limitations of this study include the absence of critical clinical data and conditions strongly linked to outcomes in AS, such as coronary arterial disease, paroxysmal atrial fibrillation, hypertension, and diabetes. Additionally, this cohort is limited to patients from specialized centers or clinics in Australia only.

In summary, the authors propose the use of the diastolic echocardiographic metrics of LAVI and E/e′ ratio in addition to the systolic metrics of LVEF and peak TR velocity in the risk stratification models of patients with nonsevere AS. They advocate their use will better inform prognostication, the timing of surveillance intervals, and the timing of interventions.

References

1. Nishimura RA, Otto CM, Bonow RO, et al. 2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *J Am Coll Cardiol* 2014; 63:e57.
2. Helmut Baumgartner, Volkmar Falk, Jeroen J Bax, Michele De Bonis, Christian Hamm, Per Johan Holm, Bernard Iung, Patrizio Lancellotti, Emmanuel Lansac, Daniel Rodriguez Muñoz, Raphael Rosenhek, Johan Sjögren, Pilar Tornos Mas, Alec Vahanian, Thomas Walther, Olaf Wendler, Stephan Windecker, Jose Luis Zamorano, ESC Scientific Document Group, 2017 ESC/EACTS Guidelines for the management of valvular heart disease, European Heart Journal, Volume 38, Issue 36, 21 September 2017, *Pages* 2739–2791, https://doi.org/10.1093/eurheartj/ehx391
3. Otto, C. M., Nishimura, R. A., Bonow, R. O., Carabello, B. A., Erwin, J. P., Gentile, F., Jneid, H., Krieger, E. V, Mack, M., McLeod, C., O'Gara, P. T., Rigolin, V. H., Sundt, T. M., Thompson, A., & Toly, C. (2021). 2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *Circulation,* 143(5), e72–e227. https://doi.org/10.1161/CIR.0000000000000923

LITERATURE REVIEWS

The Prognostic Value of Right Atrial Strain Imaging in Patients with Precapillary Pulmonary Hypertension

Hasselberg N, Kagiyama N, Soyama Y, et al. *J Am Soc Echocardiogr* 2021;34:851-61

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Background

The ability to determine prognosis in patients with pulmonary hypertension (PH) is very important, as it helps to determine which patients to refer for advanced therapies or eventual lung transplantation. While right heart catheterization is often considered the gold standard for assessing the severity of PH, the invasive nature of this procedure has led physicians to search for alternative modalities that can also offer prognostic potential. Several 2-dimensional echocardiographic parameters that relate to right ventricular (RV) size and function, including right atrial (RA) size, tricuspid annular plane systolic excursion (TAPSE), and RV fractional area change have been associated with outcomes in pulmonary hypertension.[1,2] More recently, RV strain using speckle-tracking echocardiography has been examined as a marker of worsening RV function and outcomes, with promising results.[3] The assessment of RA strain using speckle-tracking technology has also been shown to be feasible and reproducible;[4] thus the authors hypothesized that RA strain would provide additional prognostic usefulness to existing measures of RA and RV size and function in patients with precapillary pulmonary hypertension.

Methods

The study retrospectively examined consecutive patients who were referred for clinical evaluation of PH by right heart catheterization. Precapillary PH was defined by a mean pulmonary artery pressure (PAP) >25 mmHg at rest, a pulmonary artery wedge pressure <15 mmHg, and a pulmonary vascular resistance > 3 Wood units. Patients with a left ventricular (LV) ejection fraction < 50%, significant valvular disease, or PH secondary to an atrial septal defect were excluded, as were those with missing or poor quality imaging, leaving 151 patients who were included in the analysis. Sixteen age- and sex-matched healthy volunteers were used as controls. RA strain was assessed using commercially available software designed for LV strain (2D Cardiac Performance Analysis version 4.5.2.5; TomTec Imaging Systems, Munich, Germany) from the apical four-chamber view, tracing the endocardial borders in ventricular end-systole. Borders were adjusted to achieve an RA wall thickness of 2-3 mm, and manual adjustment was encouraged to optimize tracking. Peak longitudinal strain values from each of the six segments were averaged produce RA peak longitudinal strain.

Results

The 151 PH patients included in the study had a mean age of 55 years and 73% were women, which were similar to the control subjects. The majority of PH patients had idiopathic PH (51%) or connective tissue disease (33%). Routine echocardiography was performed within two months of the right heart catheterization, and revealed TAPSE, RV fractional area change, and RV global and

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free wall strain values that were below normal limits, and reduced compared to those of the control group. RA peak longitudinal strain assessment was feasible in 93% of patients. RA peak longitudinal strain values were reduced and were significantly associated with invasive measures of RA pressure, systolic PAP, cardiac output, and cardiac index ($p<0.001$ for all parameters) in the PH patients. RA peak longitudinal strain was also associated with echocardiographic measures of RV function, including TAPSE ($r=0.50$, $p<0.0001$) and RV global longitudinal strain ($r=0.47$, $p<0.001$).

During the five year follow-up period of the study, 73 of the 151 patients (48%) died. Using univariate Cox regression analyses, RV global strain, RA area, RA strain, and presence of a pericardial effusion were all associated with 5-year mortality. In multivariate analyses accounting for confounding factors, only RA strain remained independently associated with all-cause 5-year mortality ($p=0.039$). When the study patients were divided into RA strain quartiles, those in the lowest quartile (peak RA strain <25%) had a significantly increased risk of death (log-rank $p=0.006$). When RA strain (<25%) and RV strain (<15%) were combined, greater prognostic value was produced than with RV strain alone, which had previously been reported as prognostically useful in PH.5 RA strain was also found to provide improved prognostic accuracy when added to a model using clinical, hemodynamic, and echocardiographic markers of risk in PH patients.

Discussion

The functions of the atrium during the cardiac cycle can be divided into the reservoir (during ventricular contraction), conduit (during diastasis), and booster (during atrial contraction) phases. RA peak longitudinal strain offers insight into the reservoir phase, and is closely related to RV function and RA filling. Thus, it is not surprising that this and other studies have found RA strain to be impaired in PH patients.[6,7] RA strain correlated only modestly with RA area, the most commonly used echocardiographic assessment of RA structure, demonstrating that it measures something different than just chamber dilation. RA strain is likely to be a more dynamic measurement, reflecting aspects of RV dysfunction, RA dysfunction and dilation, impaired RA compliance, as well as elevations in pulmonary vascular resistance and PAP.[7,8,4] The severity of RV dysfunction in PH often determines the level of patient symptoms and is one of the main causes of mortality. However, this study suggests that RA strain may be an even stronger predictor of 5-year mortality than RV strain alone, which re-affirms a similar finding by Bai, et al. in a small study of PH patients with connective tissue disease.[9] More importantly, though, is the additional prognostic value that RA strain was shown to have when added to pre-existing clinical and echocardiographic models of PH outcomes. The RA's role in helping the dysfunctional RV to manage preload reserve may explain the importance of RA function in patients with PH, and why the prognosis worsens even further when RA reservoir function becomes impaired.

There were several limitations to this study that the authors acknowledge. Most prominent is the fact that RA strain was assessed using a generic software package intended for the LV and not one optimized for assessing the RA. In addition, due to different algorithms among the various vendors who make strain analysis software, it is highly likely that RA strain values will not be consistent across software products. The authors also assessed RA strain in only one view (apical four-chamber), which does not take into account the three dimensional nature of the RA. The authors also only reported strain data for the reservoir phase of atrial activity, as data from the conduit and contractile phases was difficult to parse out, partially due to frequent rates of tachycardia. Finally, a median of 47 days passed between right heart catheterization and echocardiography, so the correlation between hemodynamic parameters and echocardiographic findings must be interpreted with care.

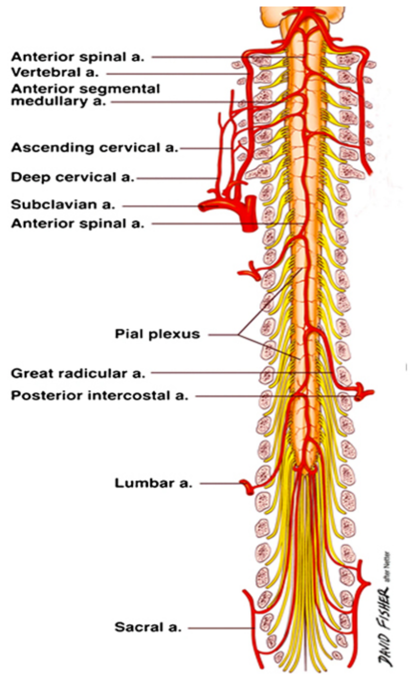
References

1. Galie N, Humbert M, Vachiery J, et al. ESC/ERS guidelines for the diagnosis and treatment of pulmonary hypertension: the Joint Task Force for the Diagnosis and Treatment of Pulmonary Hypertension of the European Society of Cardiology (ESC) and the European Respiratory Society (ERS). *Eur Respir J* 2015;46:903-75
2. Forfia P, Fisher M, Mathai S, et al. Tricuspid annular displacement predicts survival in pulmonary hypertension. *Am J Respir Crit Care Med* 2006;174:1034-41
3. Shukla M, Park J, Thomas J, et al. Prognostic value of right ventricular strain using spezckle-tracking echocardiography in pulmonary hypertension: a systematic review and meta-analysis. *Can J Cardiol* 2018;34:1069-78
4. Padeletti M, Cameli M, Lisi M, et al. Reference values of right atrial strain imaging by two-dimensional speckle tracking. *Echocardiography* 2012;29:147-52
5. Goda A, Ryo K, Delgado-Montero A, et al. The prognostic utility of a simplified biventricular echocardiographic index of cardiac remodeling in patients with pulmonary hypertension. *J Am Soc Echocardiogr* 2016;29:554-60
6. Jone P, Schafer M, Li L, et al. Right atrial deformation in predicting outcomes in pediatric pulmonary hypertension. *Circ Cardiovasc Imaging* 2017;10e006250
7. Sakata K, Uesugi Y, Isaka A, et al. Evaluation of right atrial function using right atrial speckle tracking analysis in patients with pulmonary artery hypertension. *J Echocardiogr* 2016;14:30-8
8. Ryo K, Goda A, Onishi T, et al. Characterization of right ventricular remodeling in pulmonary hypertension associated with patient outcomes by 3-dimensional wall motion racking echocardiography. *Circ Cardiovasc Imaging* 2015;8e003176
9. Bai Y, Yang J, Liu J, et al. Right atrial function for the prediction of prognosis in connective tissue disease-associated pulmonary arterial hypertension: a study with two-dimensional speckle tracking. *Int J Cardiovasc Imaging* 2019;35:1637-49

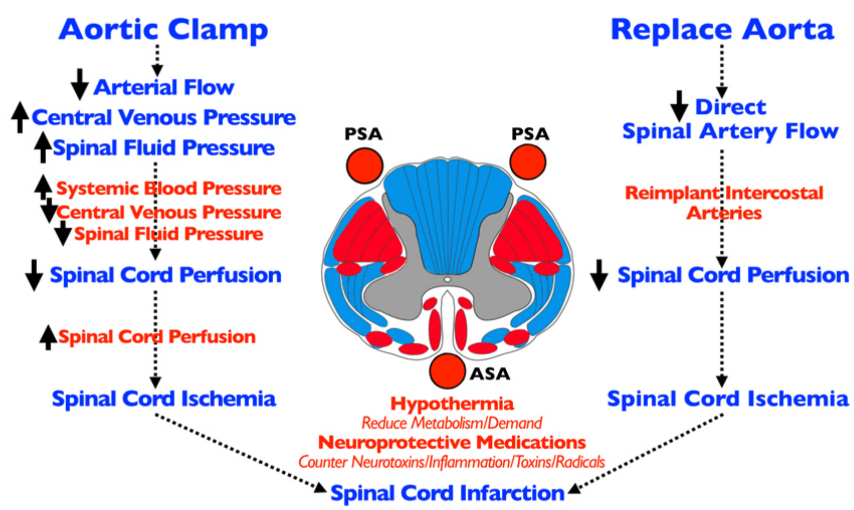
Introduction

Paraparesis and paraplegia after open thoracic aortic surgeries and for endovascular thoracic aortic procedures range from 0-10% and is associated with greater mortality. Approximately 50% resolve and 50% are long-term. Although risk factors have been identified, it is apparent that acting after the complication has occurred is less effective than preventing the complication from occurring. The actual injury is due to either a low perfusion state and/or reperfusion injury. Risk factors include a larger extent of aorta covered/resected, longer cross clamp/ischemic times, hypotension, prior aortic procedures, and irregularities of the arterial supply to the spinal cord. Below is a schematic of the arterial supply of the spinal cord demonstrating a host of feeding vessels to the anterior spinal artery (posterior not shown).

A host of surgical, procedural, and medical therapies have been described to optimize spinal cord blood flow and oxygen balance (right panel of figure). Placement of a lumbar spinal drain to monitor the pressure of and remove cerebrospinal fluid has been described. In this issue of the SCA Newsletter a Pro-Con discussion is presented to address routine placement of lumbar spinal drains is indicated for patients undergoing thoracic endovascular aortic repair (TEVAR).



Vascular Supply of the spinal cord. The spinal cord is perfused by branches of the thoracoabdominal aorta through intercostal and lumbar arteries which branch into anterior and posterior spinal arteries.
In addition, upper segments are perfused by branches from cervical and vertebral arteries.
(Reprinted with permission from Tatera et al Neuroradiology 2019 https://doi.org/10.1007/s00234-019-02207-y)



Spinal cord ischemia pathway written in blue word. Counter measures are written in red.
Spinal cord perfusion is determined by oxygen supply/demand.
Spinal cord perfusion is related to systemic blood pressure, cerebral spinal fluid pressure, and venous pressure.
PSA = Posterior spinal artery. ASA = Anterior spinal artery
(Reprinted/Adapted with permission from Wynn et al J Cardiothoracic Vasc Anesth 2014;28:1088-1099)

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Lumbar Cerebrospinal Fluid Drainage for Thoracoabdominal Surgery

PRO

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PRO: Paraplegia following thoracoabdominal aortic surgery for dissections and aneurysms remains a devastating complication that occurs in 2-10 % of patients upon wakening from anesthesia.[1,2] In addition, up to 10% of patients experience delayed neurologic dysfunction.[2] The risk of spinal cord ischemia is inherent to this procedure with a higher incidence is related to increasing complexity of the surgery and patient's comorbidities. Although data have shown that paraplegia is more common after an open repair vs. endovascular repair (TEVAR), one study showed that endovascular repair had a higher incidence of paraplegia than an open repair (13.5% vs. 7.4%) and a similar permanent paralysis rate.[3] Neurologic injury, whether occurring immediately or delayed, is due to a reduction in spinal cord perfusion.[2,4] Early detection of ischemia/dysfunction and immediate implementation of therapy improves spinal cord perfusion and outcome.[4,5]

The spinal cord receives its blood supply from anterior and posterior spinal arteries with contributions from intercostal arteries. The upper thoracic segments are perfused by branches from cervical and vertebral arteries. Spinal cord perfusion is also maintained by an extensive network of collateral vessels. Perioperative spinal cord ischemia during aortic surgery is due to decreased perfusion from primary and/or collateral vessels either by coverage, ligation (open procedures) or thrombosis. Risk factors of spinal cord ischemia and injury include emergency presentation, more extensive aneurysms, greater length of thoracic aortic coverage (> 20 cm), coverage of the left subclavian artery, ligation/coverage of intercostal/collateral vessels, prior abdominal aortic repair (loss of lower cord collateral supply), severe aortic atheromatous disease, and perioperative hypotension.[2,4,5,6]

For open procedures, interruption of spinal cord blood flow during aortic cross clamping is ischemia time. The open procedure may or may not include reimplantation of perfusing arteries. When the cross-clamp is removed, perfusion is restored. Ischemia during TEVAR is similarly due to reductions in spinal cord perfusion, however, there is no 'cross clamp-ischemic time'. Once placed, the stent graft establishes a new perfusion/flow pattern without reimplanted arterial vessels. Therefore, it is conceivable that injury may be equal to or greater during TEVAR compared to an open aortic procedure.[3]

Since neurologic outcome and recovery from injury are related to severity of and time to detection and management of dysfunction, delays of detection and management increase risk of long-term sequelae.[1,2,3,4,7] While procedural and patient risk factors for injury are described, detection while under anesthesia is difficult. Neuromonitoring of somatosensory and motor evoked potential has been used, but it is not routinely employed, and specificity is low.[1,4,8] Loss of sensory and motor signals were reported in 26% and 50% respectively during open thoracoabdominal surgeries[8] and up to 63% for TEVAR.[1] Although presumed to result from spinal cord ischemia, signal changes also occur due to effects of anesthetic agents and/or changes in patient temperature.[1] Therefore 'early' detection during the surgical procedure is difficult and emphasis on prophylactic measures to augment spinal cord perfusion are emphasized.[1,4,8]

Injury prevention before, during, and after the cross-clamp period or placement of the aortic stent is directed at reducing cord metabolism and/or augmenting spinal cord perfusion.[2,4,5,6] Techniques used to prevent spinal cord injury during open aortic procedures include extracorporeal bypass with moderate hypothermia, epidural cooling, steroid administration, and reimplantation of intercostal arteries.

Increasing spinal cord perfusion for both open aortic surgery and TEVAR includes pharmacologic augmentation of systemic blood pressure to increase perfusion through primary and collateral vessels. In addition, lowering cerebrospinal pressure by draining cerebrospinal fluid (CSF) has been advocated. Experimentally, in an aortic cross clamp model, drainage of CSF and lowering CSF pressure improves spinal cord perfusion, reduces reperfusion injury, and are associated with improved functional outcomes.[9,10]

SPINAL CORD PERFUSION PRESSURE

$$\underline{SCPP = MAP - CSFP}$$

where SCPP = spinal cord perfusion pressure
MAP= mean aortic pressure
CSFP= cerebrospinal fluid pressure

Maintaining or raising SCPP is critical in reducing or preventing SCI. Maintaining CSF pressure below 10-15 mm Hg combined with permissive hypertension, the spinal cord perfusion pressure is maintained at a higher level.[1,2,3,4,5,6] Both Coselli et al. and Safi et al have demonstrated a significant decrease in postoperative neurological deficit with the use of lumbar CSF drainage.[11,12] In a single institution study, perioperative CSF drainage (< 15 mmHg), combined with systemic pressure augmentation (mean > 90 mmHg) in patients undergoing TEVAR showed significantly reduced incidence of post-operative spinal cord injury.[6] From this study, the authors reported that prior abdominal aortic surgery, extensive aneurysm coverage and coverage of the left subclavian artery takeoff were risk factors for neurologic injury.[6]

The decision to place a spinal drain varies among institutions and according to risk predictors, the latter including procedural and patient variables as described above. Since experts agree that early detection and implementation of therapy reduces long term neurologic dysfunction,[2,8,13,14] and without accurate intraoperative neuro-monitoring,[1,8] the first detection of dysfunction will be upon emergence from anesthesia which constitutes a delay in diagnosis. Therefore, CSF drains, placed prophylactically, prior to surgery, in combination with systemic pressure augmentation is the best way to optimize spinal cord perfusion.[2,8,13] Others have described 'rescue' lumbar spinal drain placement 'as needed' based on the postoperative neurologic exam, delayed onset of paraplegia, and/or CSF drain malfunction.[2,8,14] While data supporting this practice varies, neurologic dysfunction is high.[2,11,15] Variability between studies and from one aortic center to another reflect procedural and patient variabilities and the risk of neurologic injury. In addition, emergent placement of a CSF drain may not be possible due to contraindications including a coagulopathy or the absence of a qualified person to place the drain. Delayed placement of CSF drains has been associated with worse outcomes.[14,16]

PLACEMENT OF THE CSF DRAINAGE CATHETER

Lumbar drains are placed either pre- or post-operatively for thoracic aortic aneurysm (TAA) repairs. The patient's medical history is reviewed for potential

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contraindications to insertion including recent anti-platelet (e.g. aspirin, clopidogrel, etc.) and anti-coagulant medications (Factor II inhibitors, Factor X inhibitors; heparins, coumadin etc.), laboratory evidence of a coagulopathy, infection at the insertion site, history of cerebral hemorrhage, and elevated intracranial pressure. A history of prior back surgery and lower extremity neuropathy are examples of relative contraindications.

The placement is usually done in an awake patient to allow patient feedback (pain/paresthesia). After the patient's consent, the patient is placed in a sitting or lateral decubitus position.

The sitting position allows location of the midline. The iliac crests are typically used to define the L4-5 interspace. Either L4-5 or L3-4 space can be used. Under aseptic precautions, the skin is infiltrated with preservative free 1% lidocaine solution with a 22-25G needle. A 14G Tuohy needle is then inserted at the interspace with slow advancement until there is CSF return. A flexible small multi-orifice silastic lumbar catheter is inserted to about 10 cm. The catheter can be inserted either with or without a guidewire. Once the catheter is inserted, the needle is removed. The guide wire is then removed. The catheter is connected to an external CSF drainage system. The catheter is withdrawn slightly if paresthesia occurs. The catheter is secured with a sterile clear dressing. The draining system is set to maintain CSF pressure around 5-15mmHg.[6,17] Periodic evaluation should be done regarding the amount of CSF drained.

Complications specific to CSF drains vary in incidence (0-11%) with serious complications being uncommon to rare (< 1%).[5,15,17,18,19,20,21] Complications include catheter fracture (0- 1.8%), CSF leak (0- 2.5%), post-dural puncture headache (4%), neuraxial hematoma (0- 3.3%), intracranial hemorrhage (0- 5.5%), infection (0- 1.2%) and non-functionality of the drain.[5,17,20,21] Neuraxial and subdural bleeds were rarely associated with a serious outcome.[18,20] Excessive drainage can lead to a subdural hematoma. Therefore, an intermittent drainage with monitoring of CSF pressure is advisable. CSF drainage is typically kept < 20 ml/hr and CSF pressure kept between > 4 mmHg and < 10-15 mmHg.[4,5,6,8] Exceptions are considered individually based on neurologic function and team discussion.[17] A "bloody tap" may result in delaying or postponement of surgery, therefore, when possible, drains are placed the day prior to surgery. We have often used an ultrasound to guide the location of the needle insertion. Post-operatively hemodynamics and neurological status are monitored. Prolonged or excessive drainage should be avoided. When compared to the high morbidity and mortality associated with spinal cord injury, complications directly related to CSF drains are relatively minor.[18,20] Comparing publications, those reporting larger number of cases also report fewer complications.[17]

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REMOVAL OF CATHETER AND ANTOCOAGULATION

Normally the drain is left for 48- 72 hours. The patient's coagulation status is checked and corrected if needed. The catheter is first clamped. If the patient remains asymptomatic the catheter is removed.

CONCLUSION

Despite new surgical techniques and preventative measures, spinal cord injury remains the most devastating complication following TAA surgery and TEVAR. Early diagnosis and implementation of therapy improves neurologic outcome, however, detection of neurologic dysfunction upon wakening from anesthesia is considered 'delayed'. Therefore, prophylactic placement of lumbar spinal drain, drainage of CSF and lowering CSF pressure combined with systemic blood pressure augmentation is the best method to raise spinal cord perfusion. Postoperative placement of CSF drains relies on absence of contraindications for and availability of caregivers to place a CSF drain. Since the risks of CSF drains is low, and even lower with increased experience, routine placement of CSF drains is warranted for major aortic procedures and especially for those who are considered high risk for neurologic injury.

References

1. Awad H, Ramadan ME, El Sayed HF, Tolpin DA, Tili E, Collard CD. Spinal cord injury after thoracic endovascular aortic aneurysm repair. *Can J Anaesth*. 2017;64(12):1218-1235.
2. Cheung AT, Weiss SJ McGarvey ML, Stecker MM, Hogan MS, Escherich A, Bararia JE: Interventions for reversing delayed-onset postoperative paraplegia after thoracic aortic reconstruction. *Ann Thorac Surg* 2002; 74:413-421.
3. Rocha RV, Lindsay TF, Friedrich JO, et al. Systematic review of contemporary outcomes of endovascular and open thoracoabdominal aortic aneurysm repair. *J Vasc Surg*. 2020;71(4):1396-1412.e12.
4. Ullery BW, Wang GJ, Low D, Cheung AT: Neurologic complications of thoracic endovascular aortic repair. *Sem Cardiothoracic Vasc Anesth* 2011;15:123-140.
5. Fedorow CA, Moon MC, Mutch WA, Grocott HP. Lumbar cerebrospinal fluid drainage for thoracoabdominal aortic surgery: rationale and practical considerations for management. *Anesth Analg*. 2010;111(1):46-58.
6. Hnath JC, Mehta M, Taggert JB, et al. Strategies to improve spinal cord ischemia in endovascular thoracic aortic repair: Outcomes of a prospective cerebrospinal fluid drainage protocol. *J Vasc Surg*. 2008;48(4):836-840. .
7. Wynn MM, Acher CW: A modern theory of spinal cord ischemia/injury in thoracoabdominal aortic surgery and its implications for prevention of paralysis. *J Cardiothorac Vasc Anesth* 2014;28:1088-1099.
8. Estrera AL, Sheinbaum R, Miller III CC, Harrison R, Safi HJ: Neuromonitor-guided repair of thoracoabdominal aortic aneurysms. *J Thorac Cardiovasc Surg* 2010;140:S131;S135.
9. Bower TC, Murray MJ, Gloviczki P, Yaksh TL, Hollier LH.Effects of thoracic aortic occlusion and cerebrospinal fluid drainage on regional spinal cord blood flow in dogs: correlation with neurologic outcome. *J Vasc Surg*1988; 9:135– 44.

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10. Dasmahapatra HK, Coles JG, Wilson GJ, Sherret H, Adler S, Williams WG, Trusler GA. Relationship between cerebrospinal fluid dynamics and reversible spinal cord ischemia during experimental thoracic aortic occlusion. *J Thorac Cardiovasc Surg* 1988;95:920–3.
11. Coselli JS, LeMaire SA, Köksoy C, Schmittling ZC, Curling PE. Cerebrospinal fluid drainage reduces paraplegia after thoracoabdominal aortic aneurysm repair: results of a randomized clinical trial. *J Vasc Surg*. 2002 Apr;35(4):631-9.
12. Safi HJ, Miller III CC, Huynh TTT, Estrera AL, Porat EE, Winnerkvist AN, Allen BS, Hassoun HT, Moore FA: Distal aortic perfusion and cerebrospinal fluid drainage for thoracoabdominal and descending thoracic aortic repair. *Ann Surg* 2003;238:372-381 doi: 10.1097/01.sla.000086664.90571.7a.
13. Sandhu HK, Evans JD, Tanaka A, Miller III CC, Safi HJ, Estrera AJ: Fluctuations in Spinal Cord Perfusion Pressure: A Harbinger of Delayed Paraplegia After Thoracoabdominal Aortic Repair. *Seminars in Thorac Cardiovasc Surg*. 2017:29:451-459.
14. Aucoin VJ, Eagleton MJ, Farber MA, Oderich GS, Schanzer A, Timaran CH, Schneider DB, Sweet MP, Beck AW: Spinal cord protection practices used during endovascular repair of co*mplex aortic aneurysm by the US aortic research consortium*. J Vasc Surg 2021;73:323-330.
15. Kakinohana, M. What should we do against delayed onset paraplegia following TEVAR? *J Anesth 2014;* 28, 1–3.
16. Anwar MA, Al Shehabi TS, Eid AH. Inflammogenesis of secondary spinal cord injury. *Front Cell Neurosci* 2016;10:98.
17. Estrera AL, Sheinbaum R, Miller CC, Azizzadeh A, Walkes JC, Lee TY, Kaiser L, Safi HJ. Cerebrospinal fluid drainage during thoracic aortic repair: safety and current management. *Ann Thorac Surg*. 2009 Jul;88(1):9-15.
18. Hanna JM, Anderson ND, Aziz H, Shah AA, McCann RL, Hughes GC: Results with selective preoperative lumbar drain placement for thoracic endovascular aortic repair. *Ann Thorac Surg* 2013;95:1968-1975.
19. Mazzeffi M, Abuelkasem E, Drucker CB,et al: Contemporary single-center experience with prophylactic cerebrospinal fluid drainage for thoracic endovascular aortic repair in patients at high risk for ischemic spinal cord injury. *J Cardiothorac Vasc Anesth* 2018;32:883–9.
20. Alqaim M, Cosar E, Crawford AS, et al. Lumbar drain complications in patients undergoing fenestrated or branched endovascular aortic aneurysm repair: Development of an institutional protocol for lumbar drain management. *J Vasc Surg*. 2020;72(5):1576-1583.
21. Wynn MM, Sebranek J, Marks E, Engelbert T, Acher CW. Complications of spinal fluid drainage in thoracic and thoracoabdominal aortic aneurysm surgery in 724 patients treated from 1987 to 2013. *J Cardiothorac Vasc Anesth*. 2015;29(2):342-350.

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Are the Risks Outweighing the Benefits of Lumbar Drains for Thoracoabdominal Endovascular Aortic Repair (TEVAR)?

CON

INTRODUCTION

Crawford was the first to introduce a classification framework according to the anatomic extent of aortic involvement for thoracoabdominal aortic aneurysms (TAAA) in 1986.[1] Thoracoabdominal endovascular aortic repair (TEVAR) is a minimally invasive surgical procedure in which a stent graft is deployed to cover the diseased section of the thoracic aorta as an alternative to open repair in high-risk patients with thoracic aortic disease. TEVAR was first reported in 1994 and received United States Food and Drug Administration approval in 2005.[2] TEVAR's popularity has grown and its indications include type B aortic dissection with malperfusion or rupture, traumatic aortic transection, and penetrating aortic ulcer, making it the mainstay of care for thoracic aortic diseases.[3]

TEVAR VERSUS OPEN REPAIR

Despite the lack of randomized, prospective clinical trials, review of more than 11,000 patients undergoing descending thoracic aorta cases between 2004-2007 found that when compared to open repair, the minimally invasive approach resulted in drastic reductions in peri-operative mortality (7.4% TEVAR compared to 18.5% open) regardless of the indication or sub-categories of pathology: aneurysm, rupture, and dissection.[4] As may be expected with improvements in perioperative mortality, there is an accompanying reduction in clinically significant rates of acute kidney injury, ICU length of stay, and total hospital stay.[5,6] The benefits of TEVAR are so profound that 87.9% of blunt thoracic aortic injuries were repaired by this technique between 2007 and 2015.[6] In a large systematic review and meta-analysis of comparative nonrandomized studies involving 5,888 patients that examined endovascular aortic repair vs open surgical repair for descending thoracic aortic disease, Cheng D, et al. showed that the incidence of paraplegia and paraparesis is 3.4 % in TEVAR vs. 8.2 % in open repair.[7]

The benefits of TEVAR lie in the difference in approach. Traditional techniques require large open incisions in the chest and abdomen compared to small incisions in the groin for TEVAR. Given the location of the aortic pathology, a high aortic cross clamp is required for open repair. This complete interruption of blood flow with aortic cross clamp and more superior clamp location are associated with increased mortality.[8]

COMPLICATIONS OF TEVAR AND PERIOPERATIVE MORBIDITY AND MORTALITY

Even with successful operations for aortic pathology, there are still considerable causes of morbidity. The greatest of these risks is spinal cord injury (SCI) resulting in transient or permanent paraplegia. Such a grave complication is not uncommon, however the precise incidence is unknown with the reported incidence in the published literature ranging from 3% to 6%.[9,10] The mechanism for SCI is

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interruption or reduction of blood flow to the spinal cord resulting in either transient or permanent ischemia of spinal nerves, particularly in watershed areas. This is the primary focus of risk reduction and the reason for placement of lumbar drains (LDs).

SPINAL PERFUSION

The spinal cord's main blood supply is provided by three major vessels which originate from the two vertebral arteries in the neck: one anterior artery that supplies the anterior two-thirds of the spinal cord and two smaller posterior arteries that supply the posterior one-third of the spinal cord. Additional blood supply to the spinal cord is via collateral segmental arteries. Segmental arteries arise in pairs directly from the posterior aspect of the descending aorta in the thoracolumbar level. In the thoracic area, there are nine pairs of posterior intercostal arteries and one pair of subcostal arteries. In the lumbar area, there are four pairs of lumbar arteries. These segmental arteries branch off at the intervertebral foramina to form the anterior and posterior radicular arteries. The artery of Adamkiewicz (or great anterior radiculomedullary artery) is the largest of these segmental arteries and originates from the left side of the aorta between T8 and L2.[11] In addition to these thoracic arteries the spinal perfusion also receives collateral blood flow from the lumbar and pelvic systems.[12] Perfusion of the spinal cord is dependent on the spinal cord perfusion pressure (SCPP) which is equal to the difference between mean arterial pressure and either lumbar cerebrospinal fluid (CSF) pressure or central venous pressure, whichever is greater.

ETIOLOGY AND PATHOPHYSIOLOGY OF SPINAL CORD ISCHEMIA/ INFARCTION FOLLOWING TEVAR

The mechanism for SCI is interruption or reduction of blood flow to the spinal cord resulting in either transient or permanent ischemia of spinal nerves, particularly in watershed areas. When blood flow to the spinal cord is disrupted, several localized events occur, including the generation of free radicals or the buildup of toxins, which can lead to secondary cell damage and death. Even after blood flow to the spinal cord is restored, these toxins and free radicals can continue to cause cellular damage. In open TAAA, lumbar CSF pressure rises approximately 85% above baseline following placement of the aortic cross clamp.[13] This elevation of CSF pressure will result in diminished SCPP. While there is a temporary interruption of blood flow during stent deployment, TEVAR does not require the use of an aortic cross clamp resulting in continuous blood flow to the spinal cord via the collateral circulation. The probability of SCI in both open surgery and TEVAR is dependent upon the number of segmental arteries that are covered. In studies by Amabile P et al. and Feezor RJ et al., the length of aortic coverage was and independent risk factor for SCI. (Fig.1)[14,15] Additionally, the inferior extent of the graft increased the incidence of compromising the artery of Adamkiewicz and the development of SCI.[15]

CON

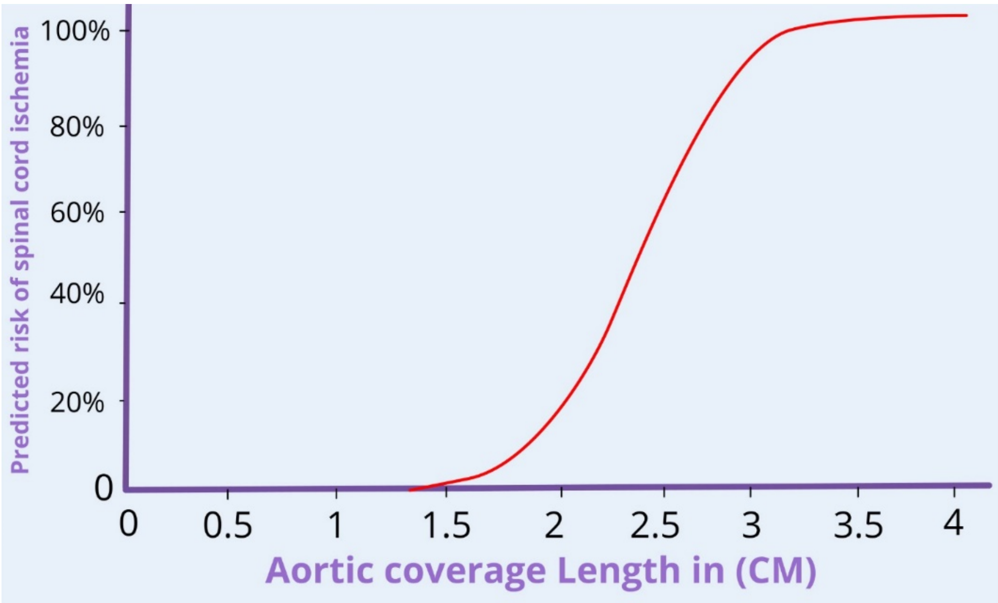

FIGURE 1: Predicted risk of ischemia in the spinal cord and its relationship to the endoluminal length of the aorta covered. Drawn by Awad and Adapted from Amabile P, et al, "Incidence and Determinants of Spinal Cord Ischaemia in Stent-graft Repair of the Thoracic Aorta" *Eur J Vasc Endovasc Surg* Vol 35, April 2008.[14]

THE POTENTIAL COMPLICATIONS OF LUMBAR CEREBROSPINAL FLUID DRAINAGE

Invasive procedures, including LDs, carry the risk of complications. There are numerous studies describing a variety of complications associated with spinal drain insertion.[16-20] A large meta-analysis by Rong et al. of 34 studies with over 4700 patients found the overall LD complication rate to be 6.5% with rates of mortality directly related to the LD as 0.9%. There was no difference in complication rates between the open and endovascular approaches, or between the different CSF drainage protocols. The complications in this analysis were classified as mild, moderate or severe, with severe complications having an incidence of 2.5% (Table 1).[19] There are also reports of the LD becoming lodged in the spinal canal and requiring a return to the operating room for removal under anesthesia.[16,21] Plotkin et al. studied 309 consecutive LDs placed for TEVAR and found that there was no difference in the incidence or types of LD complications relative to the timing of placement. Prophylactic and emergent therapeutic placement had similar rates of complications.[18]

Mild	Moderate	Severe
Puncture Site Bleeding	Spinal Headache	Epidural Hematoma
Bloody Spinal Fluid	CSD Leak Requiring Intervention (Blood Patch or Suturing)	Intracranial Hemorrhage
CSF Leak not Requiring Intervention	Drain Fracture Requiring or not Requiring Surgical Removal	Subarachnoid Hemorrhage
Hypotension		Meningitis
Drain Fracture Left in Place		Catheter/Drainage Related Neurological Deficit
Occluded/Dislodged Catheters		

TABLE 1: Complications associated with lumbar drains[19]

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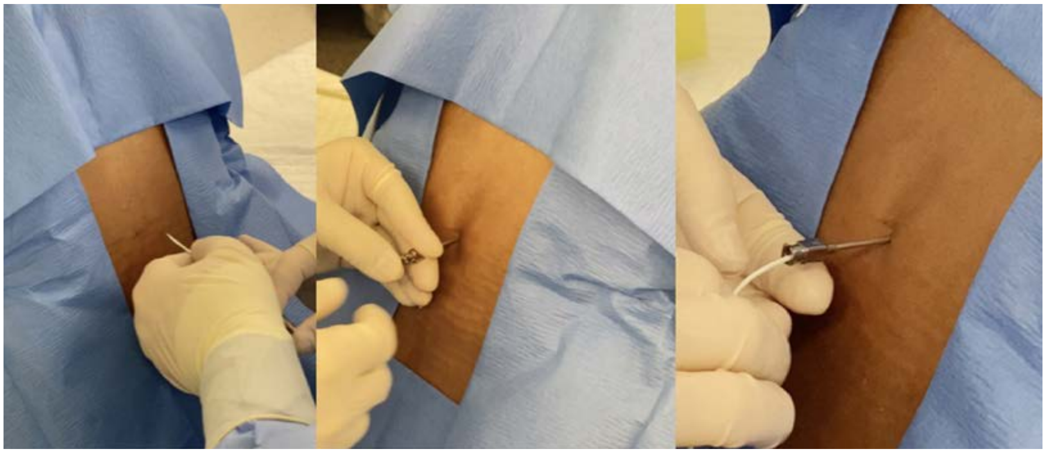


FIGURE 2: Lumbar drain placement in patients for TEVAR are subjected to unnecessary risks

THE CLAIM

- LD is considered a Class I indication in the 2010 ACCF/AHA Guidelines for the Diagnosis and Management of Patients with Thoracic Aortic Diseases and is recommended as a spinal cord protective approach in open and endovascular thoracic aortic repair for patients at significant risk of spinal cord ischemia (benefits outweighs the risk and the procedure should be done).[22]

- In a systematic review of three randomized controlled studies on LDs for open TAAA repair conducted by Kahn et al, the available evidence demonstrated that LDs are an effective addition to other therapies in preventing spinal cord ischemia.[23]

- There is a risk of conversion to open surgery.

According to these broad recommendations, the **prophylactic placement** of a lumbar spinal drain in every patient scheduled to have a TEVAR procedure might be justified.

THE CASE

A thorough examination of the current published data on the role of LDs in preventing spinal cord ischemia in patients having TEVAR (versus open TAAA repair) raises doubts. The clinical data supporting the efficacy of LDs has been difficult to gather from individual research due to the limited sample size and variability in early research.

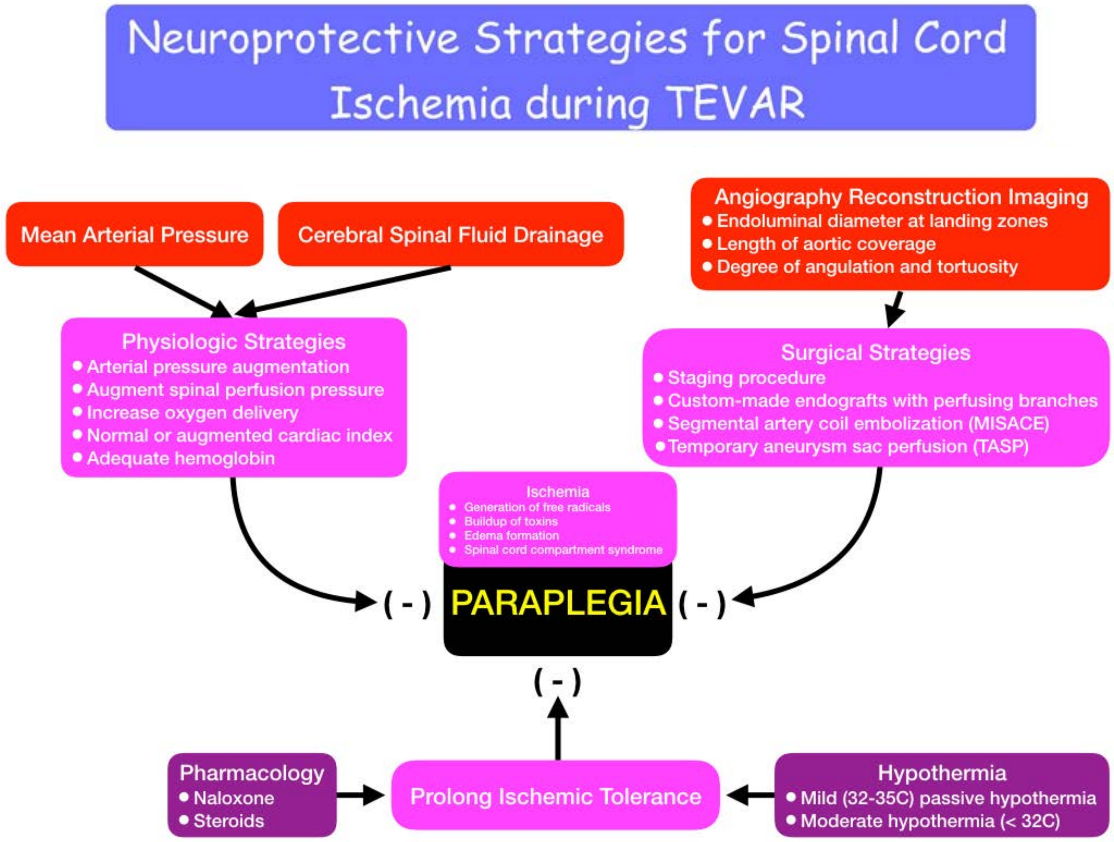
- The 2010 ACCF/AHA guidelines for thoracic aortic disease recommendations are for both open and endovascular repair but unfortunately the evidence for using LDs is based on **three small prospective randomized trials** published between 1991-2002 which evaluated patients having open TAAA repair.[23-25] These guidelines recommend placement of LDs for all open and endovascular repairs; however, multiple authors recommend reserving this procedure in TEVARs "for those patients at high risk of SCI" (class 1b). Recommendations to prevent SCI during TEVAR are based on data extrapolated from flawed studies. It is well documented that open repair benefits greatly from LDs with rates of SCI being reduced by upwards of 80%.[24] While some institutions have continued to find benefit in LDs for open and endovascular repair, there are reports that CSF drainage may not be beneficial for endovascular repair as placement of LDs is not a procedure devoid of risks.[26,27]

- The 2015 European Association for Cardiothoracic Surgeons recommend that LDs should be considered in patients undergoing TEVAR to prevent SCI. This recommendation is based only on expert opinion with class IIaC evidence.[28]
- Animal studies examining the effect of CSF drainage on blood flow to the spinal cord found no significant improvement in spinal cord tissue perfusion from CSF drainage.[29]
- The numerous physiological and hemodynamic changes that occur with the application and removal of the aortic clamp and with extracorporeal circulation during open TAAA impact the incidence of SCI. These changes are avoided with TEVAR, resulting in a substantially lower incidence of SCI.
- All LDs do not work adequately. Alqaim et al. report that LDs in 16% of patients who had prophylactic placement were non-functional.[30]
- Combining strategies such as early identification through evoked potential monitoring and serial neurologic examination, blood pressure enhancement, and rapid intervention with placement of LDs in symptomatic TEVAR patients has resulted in a decreased occurrence of SCI. As a result, **studying the unique contribution of CSF drainage to the decreased incidence of SCI** is very difficult. The efficacy of lumbar drains for the treatment of SCI following TEVAR has not been confirmed in clinical studies.[31]
- Weissler EH, et al, in a cohort study, using an algorithm that avoided LDs in all patients (225) who underwent TEVAR for descending aortic +/- arch pathology between 2012 and 2018 at a single center. In this study, the algorithm included left subclavian artery (LSA) revascularization in cases o coverage with no preservation of antegrade flow, permissive hypertension, and use of evoked potential monitoring. Endograft coverage below T6 occurred in 81%. The LSA was fully covered in 100 patients (47%), all of whom underwent LSA revascularization. Following the use of this algorithm, **the incidence of temporary or permanent SCI was 0%. No patient required postoperative LD**.[32]
- The argument for the continued use of lumbar drains in endovascular repair despite the paucity of evidence is the risk of conversion to open surgery. **The rate of conversion in acute pathology is 5% which is less than the rate of complication from lumbar drains**.[24] The risk-benefit comparison between the severity of complications from a planned drain placement to that of possible conversion is best decided on a case-by-case basis with a discussion between the anesthesiologist and the surgeon.
- SCPP is compromised in open TAAA with CSF pressures increasing 85% above baseline following placement of the aortic cross clamp.[13] **The rise in CSF pressure in TEVAR had not been demonstrated** suggesting that prophylactic LD placement may have negligible impact on SCPP.

CON

NEUROPROTECTIVE STRATEGIES FOR SPINAL CORD ISCHEMIA DURING TEVAR

Spinal cord protection in patients undergoing TEVAR procedures, needs a multidisciplinary approach that involves participation from anesthesiologists, surgeons, and ICU staff members in the preoperative, intraoperative, and postoperative periods. Figure 3 illustrates the many neuroprotective strategies that was described to benefit TEVAR patients.



CONCLUSION

The minimal risk of spinal cord ischemia, the possibility of complications, and the lack of a physiological basis make prophylactic LD placement unnecessary in TEVAR. New studies focusing on TEVAR demonstrate that the benefit of LDs can be as prevalent as the complications they are meant to prevent. LDs should only be performed prophylactically in patients at increased risk of spinal cord ischemia or in the setting of spinal cord ischemia post TEVAR.

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References

1. Frederick JR, Woo YJ. Thoracoabdominal aortic aneurysm. *Annals of Cardiothoracic Surgery*. 2012;1(3):277-285.
2. Xiang D, Kan X, Liang H, et al. Comparison of mid-term outcomes of endovascular repair and medical management in patients with acute uncomplicated type B aortic dissection. *The Journal of Thoracic and Cardiovascular Surgery*. 2019.
3. Dake MD, Miller DC, Semba CP, Mitchell RS, Walker PJ, Liddell RP. Transluminal placement of endovascular stent-grafts for the treatment of descending thoracic aortic aneurysms. *N Engl J Med*. Dec 29 1994;331(26):1729-34. doi:10.1056/nejm199412293312601.
4. Conrad MF, Ergul EA, Patel VI, Paruchuri V, Kwolek CJ, Cambria RP. Management of Diseases of the Descending Thoracic Aorta in the Endovascular Era: A Medicare Population Study. *Annals of Surgery*. 2010;252(4).
5. Thrumurthy SG, Karthikesalingam A, Patterson BO, et al. A Systematic Review of Mid-term Outcomes of Thoracic Endovascular Repair (TEVAR) of Chronic Type B Aortic Dissection. *European Journal of Vascular and Endovascular Surgery*. 2011/11/01/ 2011;42(5):632-647. doi:https://doi.org/10.1016/j.ejvs.2011.08.009.
6. Grigorian A, Spencer D, Donayre C, et al. National Trends of Thoracic Endovascular Aortic Repair Versus Open Repair in Blunt Thoracic Aortic Injury. *Annals of Vascular Surgery*. 2018/10/01/ 2018;52:72-78. doi:https://doi.org/10.1016/j.avsg.2018.03.045.
7. Cheng D, Martin J, Shennib H, et al. Endovascular aortic repair versus open surgical repair for descending thoracic aortic disease: a systematic review and meta-analysis of comparative studies. *Journal of the American College of Cardiology*. 2010;55(10):986-1001.
8. Conway AM, Qato K, Nguyen Tran NT, Stoffels GJ, Giangola G, Carroccio A. Cross-clamp location affects short-term survival in patients undergoing open abdominal aortic aneurysm repair. *Journal of Vascular Surgery*. 2020/07/01/ 2020;72(1):144-153. doi:https://doi.org/10.1016/j.jvs.2019.09.038.
9. Drinkwater SL, Goebells A, Haydar A, et al. The Incidence of Spinal Cord Ischaemia Following Thoracic and Thoracoabdominal Aortic Endovascular Intervention. *European Journal of Vascular and Endovascular Surgery*. 2010/12/01/ 2010;40(6):729-735. doi:https://doi.org/10.1016/j.ejvs.2010.08.013.
10. Scali ST, Feezor RJ, Chang CK, et al. Efficacy of thoracic endovascular stent repair for chronic type B aortic dissection with aneurysmal degeneration. *Journal of Vascular Surgery*. 2013/07/01/ 2013;58(1):10-17.e1. doi:https://doi.org/10.1016/j.jvs.2012.12.071.
11. Charles YP, Barbe B, Beaujeux R, Boujan F, Steib JP. Relevance of the anatomical location of the Adamkiewicz artery in spine surgery. *Surg Radiol Anat*. Jan 2011;33(1):3-9. doi:10.1007/s00276-010-0654-0.
12. Jacobs MJ, Elenbaas TW, Schurink GW, Mess WH, Mochtar B. Assessment of spinal cord integrity during thoracoabdominal aortic aneurysm repair. *The Annals of thoracic surgery*. 2002;74(5):S1864-S1866.
13. Bower TC, Murray MJ, Gloviczki P, Yaksh TL, Hollier LH, Pairolero PC. Effects of thoracic aortic occlusion and cerebrospinal fluid drainage on regional spinal cord blood flow in dogs: correlation with neurologic outcome. *Journal of vascular surgery*. 1989;9(1):135-144.
14. Amabile P, Grisoli D, Giorgi R, Bartoli J-M, Piquet P. Incidence and determinants of spinal cord ischaemia in stent-graft repair of the thoracic aorta. *European Journal of Vascular and Endovascular Surgery*. 2008;35(4):455-461.
15. Feezor RJ, Martin TD, Hess Jr PJ, et al. Extent of aortic coverage and incidence of spinal cord ischemia after thoracic endovascular aneurysm repair. *The Annals of thoracic surgery*. 2008;86(6):1809-1814.

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16. Henderson R, Chow R, Morales R, Taylor B, Mazzeffi MA. Removal of an entrapped lumbar drain after thoracic endovascular aortic repair. *A&A Practice*. 2016;7(4):93-95.

17. Kärkkäinen JM, Cirillo-Penn NC, Sen I, et al. Cerebrospinal fluid drainage complications during first stage and completion fenestrated-branched endovascular aortic repair. *Journal of Vascular Surgery*. 2020/04/01/ 2020;71(4): 1109-1118.e2. doi:https://doi.org/10.1016/j.jvs.2019.06.210.

18. Plotkin A, Han SM, Weaver FA, et al. Complications associated with lumbar drain placement for endovascular aortic repair. *J Vasc Surg*. May 2021;73(5): 1513-1524.e2. doi:10.1016/j.jvs.2020.08.150.

19. Rong LQ, Kamel MK, Rahouma M, et al. Cerebrospinal-fluid drain-related complications in patients undergoing open and endovascular repairs of thoracic and thoraco-abdominal aortic pathologies: a systematic review and meta-analysis. *British Journal of Anaesthesia*. 2018/05/01/ 2018;120(5):904-913. doi:https://doi.org/10.1016/j.bja.2017.12.045.

20. Wynn MM, Sebranek J, Marks E, Engelbert T, Acher CW. Complications of spinal fluid drainage in thoracic and thoracoabdominal aortic aneurysm surgery in 724 patients treated from 1987 to 2013. *Journal of Cardiothoracic and Vascular Anesthesia*. 2015;29(2):342-350.

21. Mazzeffi M, Abuelkasem E, Drucker CB, et al. Contemporary Single-Center Experience With Prophylactic Cerebrospinal Fluid Drainage for Thoracic Endovascular Aortic Repair in Patients at High Risk for Ischemic Spinal Cord Injury. *J Cardiothorac Vasc Anesth*. Apr 2018;32(2):883-889. doi:10.1053/j.jvca.2017.12.002.

22. Foundation ACoC, Guidelines AHATFoP, Surgery AAfT, et al. 2010 ACCF/AHA AATS/ACR/ASA/SCA/SCAI/SIR/STS/SVM guidelines for the diagnosis and management of patients with thoracic aortic disease. *Journal of the American College of Cardiology*. 2010;55(14):e27-e129.

23. Khan SN, Stansby GP. Cerebrospinal fluid drainage for thoracic and thoracoabdominal aortic aneurysm surgery. *Cochrane Database of Systematic Reviews*. 2003;(4).

24. Coselli JS, LeMaire SA, Köksoy C, Schmittling ZC, Curling PE. Cerebrospinal fluid drainage reduces paraplegia after thoracoabdominal aortic aneurysm repair: results of a randomized clinical trial. *Journal of vascular surgery*. 2002;35(4):631-639.

25. Safi HJ, Miller III CC, Huynh TT, et al. Distal aortic perfusion and cerebrospinal fluid drainage for thoracoabdominal and descending thoracic aortic repair: ten years of organ protection. *Annals of surgery*. 2003;238(3):372.

26. Bisdas T, Panuccio G, Sugimoto M, Torsello G, Austermann M. Risk factors for spinal cord ischemia after endovascular repair of thoracoabdominal aortic aneurysms. *Journal of Vascular Surgery*. 2015/06/01/ 2015;61(6):1408-1416. doi:https://doi.org/10.1016/j.jvs.2015.01.044.

27. Wong CS, Healy D, Canning C, Coffey JC, Boyle JR, Walsh SR. A systematic review of spinal cord injury and cerebrospinal fluid drainage after thoracic aortic endografting. *Journal of Vascular Surgery*. 2012;56(5):1438-1447.

28. Etz CD, Weigang E, Hartert M, et al. Contemporary spinal cord protection during thoracic and thoracoabdominal aortic surgery and endovascular aortic repair: a position paper of the vascular domain of the European Association for Cardio-Thoracic Surgery†. *Eur J Cardiothorac Surg*. Jun 2015;47(6):943-57. doi:10.1093/ejcts/ezv142.

29. Horn EM, Theodore N, Assina R, Spetzler RF, Sonntag VK, Preul MC. The effects of intrathecal hypotension on tissue perfusion and pathophysiological outcome after acute spinal cord injury. *Neurosurgical Focus*. 2008;25(5):E12.

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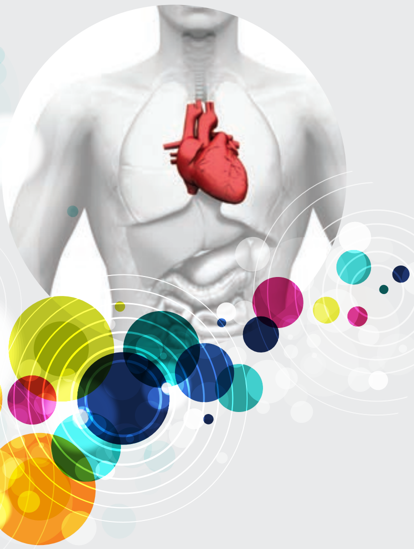

Echo Corner

ECHO CORNER UPDATE

SCA has contracted with TalentLMS for the acquisition of their eFront Learning Management System (LMS). As the LMS goes live in Q4 2021, SCA members will have greater access to online educational content, a repository of their learning history, and quick and easy access to earn CME credits and produce their certificates.

The LMS will be accessible through the SCA website and SCA Mobile App. It is important to note that the link associated with ECHO Corner Cases in the December Newsletter will connect users to the new LMS.

We look forward to providing this new functionality to serve SCA members' educational needs!