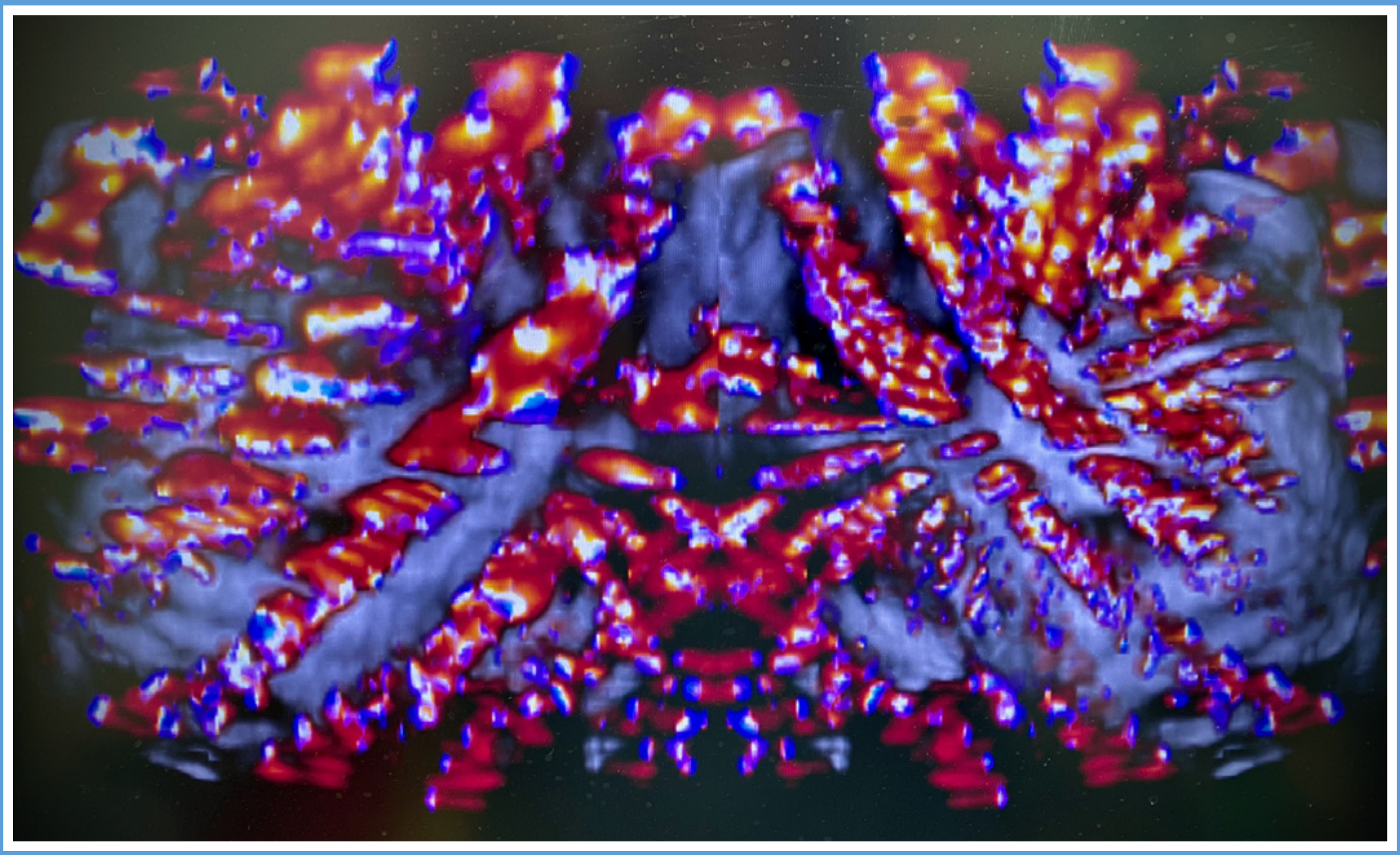
ECHO



VOLUME 11 ISSUE 10 **OCTOBER 2022**

2022-2023 EDUCATION CALENDAR

NOVEMBER

Critical Care Echocardiography Review Course

November 7-9, 2022
Rosemont, IL

Provided in partnership with ASE and the Society for Critical Care Medicine

DECEMBER

Advanced Imaging Techniques: A Virtual Experience

December 3-4, 2022

Jointly provided by ASE and the ASE Foundation

JANUARY

32nd Annual Echo Hawaii

January 16-20, 2023
Westin Hapuna Beach Resort
Kohala Coast, Big Island, HI

Jointly provided by ASE and the ASE Foundation

FEBRUARY

35th Annual State-of-the-Art Echocardiography

February 17-20, 2023
Westin Kierland Resort & Spa
Scottsdale, AZ

Jointly provided by ASE and the ASE Foundation

MAY

24th Annual ASCeXAM/ReASCE Review Course | VIRTUAL

Content Available May 2023

Jointly provided by ASE and the ASE Foundation

JUNE

34th Annual Scientific Sessions

June 23-26, 2023
Gaylord National Resort & Convention Center
National Harbor, MD

Jointly provided by ASE and the ASE Foundation

OCTOBER

11th Annual Echo Florida

October 7-9, 2023
Disney's Yacht & Beach Club Resort
Orlando, FL

Jointly provided by ASE and the ASE Foundation

Discounted rates for ASE members. *To learn more and register, visit us at **ASEcho.org/Education**.*

*This text also appears in the October JASE. **OnlineJASE.com***

Contents

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Cover art: "3D Mitral Rorschach" Michael Rubin, MD, St. Vincent's Medical Center, Bridgeport, Connecticut

(Image taken at Yale New Haven Hospital in New Haven, CT)

EDITORS' NOTE

ASE is very grateful to our members who contribute to *Echo* magazine and values their willingness to share personal insights and experiences with the ASE community, even if they may not be in total alignment with ASE's viewpoint.

MAKING GLOBAL CONNECTIONS

*Contributed by **Stephen H. Little, MD, FASE**, Cardiology Fellowship Program Director at Houston Methodist Hospital, System Director for Structural Heart, Professor of Medicine, Weill Cornell Medical College, Cornell University, and Adjunct Professor at Rice University in the Department of Bioengineering*

In July I had the opportunity to represent ASE at two international meetings. First, I was invited to speak at the (virtual) 10th Argentine Congress on Echocardiography and Cardiovascular Imaging, organized by the Argentine Society of Cardiology (SAC). The same weekend, I flew to Sao Paulo, Brazil to speak at the 11th Congress of the Department of Cardiovascular Imaging of the Brazilian Society of Cardiology (DIC) *(Figure 1)*. Both were excellently organized meetings, the faculty and attendees I met were delightful, and with one meeting held virtually and the other in person, I had the unique opportunity to be in two places at once.

I wrote in a previous column about how ASE is the home for all cardiovascular ultrasound users. That home includes our international colleagues as well. ASE Headquarters may be in the US, but we are a global organization. Today, 21% of our membership lives outside the United States, in 115 different countries. In recognition of this, we have added dedicated global representative positions on both the ASE and the ASE Foundation Boards of Directors. These directors, Kian-Keong (KK) Poh, MBBChir, FASE, from Singapore and Cathy West, MSc, AMS, FASE, from England, bring a global perspective to our decision-making, and help ensure the Society's relevance in the international field.

> ASE Headquarters may be in the US, but we are a global organization. Today, 21% of our membership lives outside the United States, in 115 different countries.

In today's challenging medical climate, it's vital that we actively develop global partnerships that serve to advance cardiovascular ultrasound. This work is overseen by our International Relations Advisory Committee, chaired by Federico Asch, MD, FASE, and Madhav Swaminathan, MD, MMCi, FASE, which help us liaise with other international, echo-focused organizations and their leadership. The ASE International Alliance Partners program was founded in 2016 to create a pathway for collaborations and shared resources among participating membership-based echocardiography and cardiology societies. Today we are proud to recognize 34 societies as collab-

Figure 1. Meeting with leaders from the Department of Cardiovascular Imaging of the Brazilian Society of Cardiology (DIC) and the Cardiovascular Imaging Society of the Inter-American Society of Cardiology (SISIAC) in Sao Paulo, Brazil.

orating partners (*Figure 2*). Expertly conducting this orchestra of partners is Andrea Van Hoever, MSGH, ASE Deputy Director.

We engage with our alliance organizations in multiple ways. ASE's guideline documents are increasingly used by the global cardiac ultrasound community, and we offer our alliance partners the opportunity to endorse ASE's new guideline documents prior to publication, and make them available to their memberships. We also collaborate with our non-English-speaking partners to translate and disseminate our practice guidelines and patient care protocols into their native languages, as well as accompanying guideline posters and webinars. Currently available in eight languages, these translations are accessible at ASEcho.org/Translations. Donations to the ASE Foundation help fund these efforts.

The value of learning opportunities that bring the global cardiovascular ultrasound community together—be they virtual or in person—cannot be overstated. Alliance organizations regularly contribute outstanding local speakers and topics of regional interest for inclusion in ASE's educational activities. And ASE leadership frequently participates as faculty in our partners' meetings. Looking ahead, we are excited to organize the next World Summit on Echocardiography, an international education and training event developed in collaboration with our alliance partners. Previous World Summits have been held in Argentina (2011), India (2013), China (2015), and Brazil (2017). We look forward to announcing the dates and location for the 2024 World Summit soon.

> The value of learning opportunities that bring the global cardiovascular ultrasound community together—be they virtual or in person—cannot be overstated

The global scientific community has also been vital to the success of the World Alliance

34 International Alliance Partners

OF THE AMERICAN SOCIETY OF ECHOCARDIOGRAPHY

ASE proudly recognizes 34 societies as ASE International Alliance Partners.

(Listed alphabetically)

Argentine Federation of Cardiology (FAC)

Argentine Society of Cardiology (SAC)

ASEAN Society of Echocardiography

Asian-Pacific Association of Echocardiography (AAE)

Australasian Society for Ultrasound in Medicine (ASUM)

Australasian Sonographers Association (ASA)

British Heart Valve Society (BHVS)

British Society of Echocardiography (BSE)

Canadian Society of Echocardiography (CSE)

Cardiac Society of Australia and New Zealand, Imaging Council (CSANZ)

Cardiothoracic Anaesthesia Society of South Africa (CASSA)

Cardiovascular Imaging Society of the Inter-American Society of Cardiology (SISIAC)

Chinese Society of Echocardiography (CSE)

College of Anaesthesiologists, Singapore (CAS)

Cuban Society of Cardiology, Echocardiography Section

Department of Cardiovascular Imaging of the Brazilian Society of Cardiology (DIC)

European Association of Cardiovascular Imaging (EACVI)

Indian Academy of Echocardiography (IAE)

Indian Association of Cardiovascular Thoracic Anaesthesiologists (IACTA)

Indonesian Society of Echocardiography (ISE)

Iranian Society of Echocardiography (ISE)

Israel Working Group on Echocardiography

Italian Association of Cardiothoracic Anaesthesiologists (ITACTA)

Japanese Society of Echocardiography (JSE)

Korean Society of Echocardiography (KSE)

Mexican Society of Echocardiography and Cardiovascular Imaging (SOME-ic)

National Association of Cardiologists of Mexico, AC (ANCAM)

National Society of Echocardiography of Mexico A.C. (SONECOM)

Philippine Society of Echocardiography (PSE)

Saudi Arabian Society of Echocardiography (SASE)

Thai Society of Echocardiography (TSE)

The Pan-African Society of Cardiology (PASCAR)

Venezuelan Society of Cardiology, Echocardiography Section

Vietnam Society of Echocardiography (VSE)

Societies of Echocardiography (WASE) Research Studies, led by Roberto Lang, MD, FASE, and Federico Asch, MD, FASE. The WASE Normal Values and the WASE-COVID studies both facilitated scientific collaborations, strengthened global relationships, and have improved the quality of patient care worldwide.

The ASE Foundation's global health outreach program is also conducted in close collaboration with our alliance partners. These events bring adult and pediatric cardiac care to areas of the world where mutual exchanges of education and training will benefit local clinicians and provide direct patient services to at-risk communities. Many of these events have introduced ASE to organizations that turn into alliance partners and have helped identify future Honorary FASE recipients–colleagues living outside the U.S. who have made significant contributions to the field and have played a strong role in building international relationships with ASE.

The goal of all of these global efforts is to share knowledge, expand thought leadership, and enhance standards and practices based on the best thinking worldwide. Fostering global connections between healthcare providers to improve patient care is at the heart of ASE's very existence. It's so important that we all embrace opportunities to learn from, and about, each other. It not only makes us better clinicians, but it also makes us better global citizens, which in turn makes ASE an even stronger professional society.

“The goal of all of these global efforts is to share knowledge, expand thought leadership, and enhance standards and practices based on the best thinking worldwide.

Stephen H. Little, MD, FASE
ASE President

This text also appears in the October Echo magazine.

Work-Related Musculoskeletal Disorders in Sonography: Ergonomics & Prevention

*Contributed Contributed by **Jill Mazal, BS, RDCS, RDMS, FASE**, Diagnostic Cardiology Manager, Sanger Heart & Vascular Institute, Atrium Health, Charlotte, NC.*

WORK-RELATED musculoskeletal disorders (WRMSDs) are painful injuries involving the muscles, tendons, ligaments, and nerves resulting from repetitive stress (cumulative trauma) and poor ergonomics in the workplace. There is a high prevalence of WRMSDs among cardiac sonographers with over 85% reporting symptoms. WRMSDs and their associated high costs (medical bills, workman's compensation, disability, and career ending impacts) are a major cause for concern. Addressing ergonomics in sonography is crucial to the longevity of our careers and more importantly, to our health, overall wellbeing, and quality of life. Understanding the importance of ergonomics and implementing tools in the echo lab can aid in the prevention and reduction of workplace injuries.

Addressing ergonomics in sonography is crucial to the longevity of our careers and more importantly, to our health, overall wellbeing, and quality of life.

Recognizing the problem

At Atrium Health Sanger Heart & Vascular Institute in Charlotte, North Carolina, we distributed an internal survey on WRMSDs specific to our cardiac sonographers. Our survey included questions on work schedules, scanning environment, ergonomic equipment, pain, and injuries. The survey results were alarming and on par with national industry data. 74% reporting having experienced work-related musculoskeletal pain (WRMSP) in the prior 12 months with almost 50% experiencing WRMSP most days (*Figure 1*). At this point, it was clear, we needed to act.

Addressing the problem

To reduce potential work-related injuries, a safe working environment must be created through identification, education, ergonomic tools and equipment, and acceptance to a culture of safety. Working diligently towards continuous education, ongoing evaluations, and implementations are key to a successful prevention program. In response to our survey, we implemented a comprehensive program to reduce and prevent WRMSDs in our lab and includes:

- Appointment of local sonographer safety

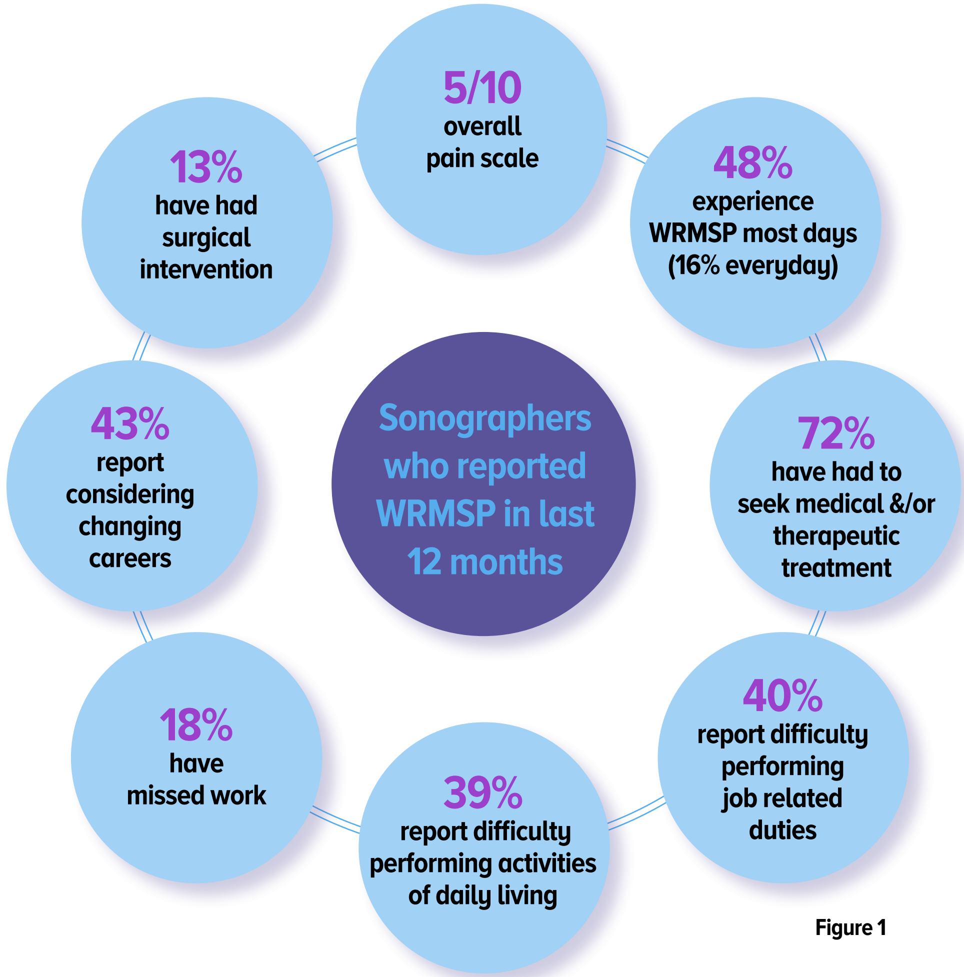


Figure 1

champions (who went through professional training) to identify unsafe conditions and behaviors, intervene with on-the-spot ergonomic scanning suggestions.

- Ergonomic equipment evaluations.
- Sonographer Safety Champion quarterly meetings to discuss needs and next steps.
- On-going Ergonomic education including didactic lectures, yearly E-learning module with post-test, new hire training and sonographer ergonomic competencies.
- Sonographer specific stretching posters and therapy bands for each site.
- Collaboration with physical therapy department to provide sonographer specific exercises and stretches according to the most common sonographer injuries identified.
- Collaboration with our local sonography school to implement ergonomics as part of their curriculum.
- Updated Ergonomics Policy & Procedure
- Provided equipment with exam specific features and adjustability for optimizing scanning posture including ultrasound systems, ergonomic exam tables, ergonomic scanning chairs, and adaptive support devices such as patient positioning wedges and arm cushions.

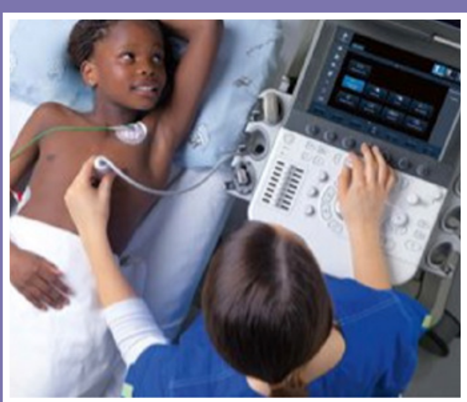
Creating a culture of safety

Everyone has a role in maintaining a culture of safety and preventing WRMSDs, leaders and teammates alike. Employers and leaders can deliver education and properly fit an ergonomic space with equipment, but solutions require behavioral changes on behalf of the sonographer. Recognition, acceptance and implementation of tools and resources are key in developing a successful program. It is the role of the sonographer to implement risk reducing modifications to scanning techniques and take personal accountability for maintaining safe work practices. Taking the time to ergonomically optimize equipment, scanning position and posture is essential. Leaders must aim for continuous education and ergonomics should be discussed and evaluated regularly. Sonography students learn good and bad habits from their preceptors. Teaching our students early, the proper way, is key to preventing WRMSDs moving forward.

At Atrium Health Sanger Heart & Vascular Institute, we are taking it a step further to support our sonographers and promote a safe and healthy work environment. We will be implementing monthly massage therapy sessions for our full-time and part-time cardiac sonographers in hopes of seeing a further reduction in symptoms and improvements in quality of life. With a dedicated team effort, we hope to prove that prevention is possible and WRMSDs are avoidable!

The Magic Triangle

The angle you place yourself between your machine and patient. Start with a straight, comfortable body core –sitting without neck or trunk twist and shoulders square to the system's monitor.



TIP 1 Rotate console away from bed to align trackball with elbow and twist.

TIP 2 Float monitor towards patient

Sonographer Ergonomic Tips

- Move the patient close to you
- Optimize the control panel (away from patient and in line with wrist and arm at 90 degrees)
- Position monitor towards patient (magic triangle) and at eye level
- Raise or lower exam table to reduce arm abduction
- Maintain neutral wrist position (scanning and non-scanning hand)
- Keep arms and elbows tucked in
- Reduce reaching of control panel and patient
- Use ergo chair & bed (drop out to avoid wrist flexion/extension)
- Keep body in straight alignment. No bending/twisting of back or neck.
- Avoid contact pressure such as leaning on patient bed/stretcher.
- Stand up to scan subcostals & SSN
- Reduce grip force and transducer pressure
- Sit or stand with weight evenly distributed on both feet
- Scan from the patient not the system (magic triangle)
- Use a support device if needed (towel, block cushion)
- Take mini/micro stretching breaks during and after your scan
- Exercise / Stretch

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Sonographer

VOLUNTEER OF THE MONTH

Congratulations

Ken Horton, ACS, RCS, FASE

Intermountain Health Institute

When and how did you get involved with cardiovascular ultrasound?

After graduating high school, I enlisted in the US Navy as a Hospital Corpsmen. One of my first assignments was the Cardiac Care Unit (CCU) at the Naval Regional Medical Center in Portsmouth Virginia. I really enjoyed the intensity and challenge of caring for critically ill cardiac patients. After working in CCU and being exposed to that environment, I decided to apply for, and was accepted to, the Navy Cardiopulmonary Technician program which is known today as the Navy Cardiovascular Technician. After four years as a Navy CVT, I applied for instructor duty at the Naval School of Health Sciences in Bethesda, Maryland. Upon arrival at NSHS I was assigned to teach the medical physics, ultrasound physics and instrumentation and Echocardiography courses. I have been involved with cardiac ultrasound ever since those days.

What is the name and type of facility/institution at which you work, and what is your current position?

I have worked for Intermountain Healthcare at the Intermountain Medical Center (IMC) in Salt Lake City, Utah for 16 years. My official title is Echo Research Coordinator. In August of this year, I transitioned from being onsite at IMC to a remote position, and I now reside just outside of Orlando, Florida. While at IMC I had one clinical day a week dedicated to scanning patients and the rest of my time was dedicated to QA, accreditation, research, and education. So, now that I am working remotely, I work full time on QA, accreditation, research, and education. Transitioning to a remote position has been quite an adjustment - for me and the echo lab! However, so far it seems to be working out.

When and how did you get involved with the ASE?

I retired from the Navy in 1999 and went to work at Georgetown University Hospital in Washington, D.C. While there, I met Neil Weissman a past-president of ASE. Shortly thereafter Neil moved over to the MedStar Research Institute and hired me to work with him in his Echo/IVUS Core Lab. I was not a member of ASE at the time, but Neil encouraged me to join, and I did. As I observed him work on his volunteer activities with the Society, I became interested in doing more myself, so I volunteered. My first assignment was the Guidelines and Standards committee which he chaired at the time. I have since been on many committees, writing groups, and task forces. He also helped me get my first speaking engagement at the Scientific Sessions in 2002.

Why do you volunteer for ASE?

I ask myself that question very frequently! Sometimes it can be challenging and sometimes it can be a tremendous amount of work. But at the end of the day, it is so gratifying knowing that your contributions are really helping to define the current profession of echocardiography as well as its' future.

ASE is also a place that I have made lifetime friendships with so many people. While I certainly benefit from the professional components of the Society, I

> **"It is so gratifying knowing that your contributions are really helping to define the current profession of echocardiography as well as its' future."**

mostly enjoy the friendships I have developed over the years.

What is your current role within ASE? In the past, on what other committees, councils, or task forces have you served and what have you done with the local echo society?

I currently serve as Member at Large on the sonographer council steering committee, and I am also the ASE representative to the Committee on Accreditation for Advanced Cardiac Sonography. Over the years I have served on multiple committees and taskforces. Through that involvement I was "invited" by my friends Peg Knoll, Marti McCulloch, and Rick Rigling to serve on the Council of Cardiovascular Sonography Board (now called steering committee). I served as a Board member and through the leadership ladder to being Chair of the Council from 2011 – 2013. I also served on the ASE Board of Directors including a term as Executive Secretary.

Anyone can be a member of ASE and enjoy the fruits of other people's hard work. But I challenge you to go beyond that and to volunteer.

What is your advice for members who want to become more involved in their profession or with the ASE?

Anyone can be a member of ASE and enjoy the fruits of other people's hard work. But I challenge you to go beyond that and to volunteer. When you see that Call for Volunteers, open it and apply for something. If you are young in your career apply for a travel grant. I can't tell you how many of my ASE friends started by getting a grant to attend the Scientific Sessions, got involved and then just grew professionally from there. If you are not a Fellow of the American Society of Echocardiography (FASE) I encourage you to apply – a lot of positions require you to be a FASE or give priority to assignments to people that hold the designation. When all else fails, reach out to any of the council steering committee members for advice.

What is your vision for the future of cardiovascular sonography?

I think the two most impactful things on the field of cardiovascular sonography are structural heart interventions and artificial (automated) intelligence (AI). Structural heart interventions have already changed the way we do echoes and the workflow in the echo lab. These interventions are requiring longer, more detailed echocardiograms utilizing more complex modalities such as 3-D and strain. They require an advanced knowledge of anatomy, physiology, and hemodynamics. I think the Advanced Cardiac Sonographer (ACS) will play a vital role in assessing structural heart disease by echocardiography as well as educating and mentoring younger cardiac sonographers to these assessments.

Echocardiography is not new to the field of AI. So many of our machines have tools on board that utilize AI in one way or another. I think where AI is really going to make a difference is bringing echocardiography to places that it has not been before. Tools that will guide non-sonographers to the best imaging windows and automated measurements such as ejection fraction and global longitudinal strain are available now. It is exciting to see how far this will go. As sonographers we need to embrace this change and be a part of it.

Introducing the

New CAVUS Steering Committee Members

*Contributed by **Fadi Shamoun, MD, FASE** (CAVUS Chair)*

Allison Hays, MD, FASE

Guidelines and Standards Committee Rep.

Dr. Allison Hays is the Medical Director of Echocardiography at Johns Hopkins, and an associate professor of medicine. In addition to leading the echo lab, she leads a research team and conducts NIH-sponsored studies focused on characterizing vascular function using ultrasound and MRI techniques with stress in high-risk patients such as people living with HIV.

Dr. Hays teaches and mentors cardiology fellows and attends regularly on the general cardiology service. In addition, she leads the Johns Hopkins Echo Integration Steering Committee, a health systems wide effort at Johns Hopkins to promote integration of non-invasive imaging systems across Johns Hopkins campuses and satellite locations and serves on the Department of Medicine Promotions committee.

In her spare time, she enjoys spending time with her husband and two school age daughters and her Devon Rex cat named Oliver. She enjoys traveling, hiking, and watching professional tennis.

Edward Gill, MD, FASE
Chair-Elect

Dr. Edward Gill is Professor of Medicine in the Division of Cardiology at the University of Colorado, Anschutz Campus. He directs the Interventional Echocardiography program, is co-director of the Hypertrophic Cardiomyopathy Clinic and is Associate Director of the Lipid Clinic.

Dr. Gill has a long-standing interest in vascular medicine as he is board certified in Echocardiography, but also Lipidology. He performs research in the area of aortic vascular cells, and has published articles on carotid IMT and coronary calcium scoring in the Journal of Clinical Lipidology. Dr. Gill is also active in research involving three-dimensional echocardiography as well as three-dimensional carotid imaging.

He has served on the ASE Board of Directors (2016-2019), CASE Editorial Board (2021-2022) and currently serves as the Chair-Elect of the FASE Training & Certification Advisory Committee.

Outside of medicine, Dr. Gill enjoys spending time with his wife and two sons and competing in slalom water-skiing.

Keith Collins, MS, RDCS, FASE
Council Representative

Mr. Collins is currently Lead Cardiac Sonographer, overseeing New Technology at Northwestern Memorial Hospital in downtown Chicago.

His focus is on the training, implementation, and continuing education, particularly using 3D, strain, and contrast imaging. After completing his term as Sonography Council Chair, Mr. Collins serves as the Council Representative on the Executive Committee of the Board of Director.

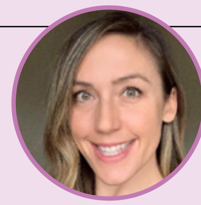
Mr. Collins is excited to be a part of CAVUS and will help to implement the action items of each Council. A former springboard diver, he loves time on the water, world travels, and cooking.

How to Promote Ergonomics and

Prevent Injury in the Echo Laboratory

Contributed by **Rita France, RDCS, RDMS, RT, FASE; Seda Tierney MD, FAAP, FASE, FACC, FAHA; Jimmy Lu, MD, FASE; Jennifer Hake, RDCS(PE/AE), RDMS(FE), FASE;** *and* **Shiraz Maskatia, MD, FASE**




INTERNATIONAL LITERATURE shows that 80% to 90% of sonographers experience pain while performing scans at some stage of their career. Of these, approximately 20% will have a career changing and life changing injury.[1] These sobering statistics are reflective of what many echo lab leaders are seeing firsthand among their staff. Many sonographers start experiencing discomfort while scanning very early in their careers, however, pain or discomfort is often under-reported in the workplace. Ergonomics education is therefore critical to protect our most important resource - our people.

The rise in work- related musculoskeletal injuries is even more problematic with the current limited workforce. Retention has become an issue for many institutions. At ASE's 2022 Scientific Sessions, a group of concerned lab managers discussed this important issue and shared what is being done in their labs to support their staff. Here are some practical approaches to prevent sonographer injury in your laboratory.

It is important to begin with the equipment in the laboratory. Vendors have addressed ergonomic issues with height adjustable carts and decks that are able to move in various planes along with deck designs that keep commonly used controls easily accessible, but there is always room for improvement. Giving feedback to your sales representatives or application

International literature shows that 80% to 90% of sonographers experience pain while performing scans at some stage of their career.

specialists is important in the development of future platforms. Beds and chairs specifically designed to improve ergonomics for the sonographer are commercially available, along with wrist wrap cable braces and sponges both for patient positioning and imaging arm and wrist support. Providing the right equipment is a necessary first step in workplace safety. In the context of budget constraints, the considerable cost of treating or losing an employee to injury should be highlighted when lobbying for that support.

Next, provide education on how the staff utilize the equipment and tools that are available to them. Consider engaging a local physical therapy group or other ergonomic resources in the institution to address staff on ways to perform their work in a way to reduce if not eliminate injury. They may suggest stretches and exercises that can be done between patients or at break in order to reduce daily strain. Images of these exercises can be posted in every room to remind staff to take a few moments throughout the day to stretch. If a staff member is experiencing continued issues, an ergonomic assessment can be requested for that staff member by a qualified physical therapist. They can be individually counseled to prevent injury and these assessments often come with recommendations that can benefit the entire staff. When a staff member has experienced injury, they should be referred to the institution's Occupational Health team for assessment and documentation of the injury. This may result in referral for physical therapy and in some cases, leads to intervention.

The rise in work- related musculoskeletal injuries is even more problematic with the current limited workforce.

Another consideration is to set up a relief station in the echo laboratory. This can include a variety of tools to provide relief from muscle strain. With input from a physical therapy group, a station was created in our main and regional clinics with a massage gun, a Theracane®, and a massage ball. The station is available to all staff to be used at breaks or after physically demanding studies. Our institution had massage chairs available previously at a charge. After attending a lecture in our laboratory by a physical therapy group, the Occupational Health team made access to the chairs free and available to be scheduled. The first six months were booked in less than a day. One of the lab managers in the group had contracted a massage therapist to come in once a month, and several were lobbying for the institution to have one or two on staff.

For those of us who are Physician leaders, we must first remember that this is a very real problem. If it were not already obvious, current staffing crises have made it even more clear that pediatric/congenital sonographers are the most important resource in our laboratories. Here are some suggestions of ways to support our friends and colleagues.

1. Listen

The data on workplace-related musculoskeletal injury are shocking. Talk to your sonographers and make sure they feel safe to answer. You may be surprised at how many are scanning with pain.

2. Re-evaluate your staffing models

Certain scans (particularly portables and fetal scans) are more demanding on the sonographer's body. How does your lab determine whether an echo is done portably vs. transportation to the lab? How does your lab distribute portables and fetal studies – rotating days, half-days – and are their limits to the number of studies? Are there limits to clinic size or number of echoes for an off-site clinic supported by a single sonographer?

3. Re-evaluate your protocols

The more time on the probe, the more stress on the body. Arguments for complete vs. focused studies are controversial, and none of us want to cut corners. However, consider whether your scan protocol includes historical images of little value. Clarify indications for repeat studies and determine the scope of the images that need to be obtained.

Many of these suggestions are easy to implement but will have a huge impact and will help create a necessary culture of safety in your laboratory.

4. Advocate for your sonographers

Clarify with your neonatology colleagues, not just the bedside nurse, what can be done to safely scan in the intensive care nursery. Are sonographers contorting their bodies to scan through portholes? Can they lower a side or raise the top? Sometimes the audience most in need of being convinced may be your sonographers themselves. Pediatric/congenital sonographers are particularly hardworking and committed, willing to do anything to get those pictures. Are there educational modules, ergonomic consults, or other resources which are available, easily accessible, and actively used in your lab? Is there an identified ergonomic champion in your lab?

Deciding what might work for your individual lab might best begin with where your staff is now in their level of need. Conduct a simple survey to assess how much pain they are having, how often, and where. We conducted a survey prior to the lecture by the physical therapy group so that they could tailor their discussion and suggestions to what our staff was experiencing. Designate a team of staff members to address these issues with some of the suggestions mentioned above to allow them to take ownership but provide the department and institutional support to make them happen. Many of these suggestions are easy to implement but will have a huge impact and will help create a necessary culture of safety in your laboratory.

Reference

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Melanie Kathol is using the Theracane.

Melanie Kathol is holding the massage gun on Ashley Warta's shoulder.

Perspectives as Trainees in

Neonatal Hemodynamics

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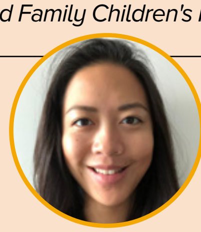


THE USE OF ECHOCARDIOGRAPHY for the assessment of hemodynamic aspects of the cardiovascular system has gained wide interest in neonatology. Clinical evaluation alone is frequently imprecise, which is compounded by the complex and dynamic nature of the transitional circulation at birth. While traditional echocardiography in the neonatal period has focused on assessment of the structure of the heart, these scans usually provide a limited snapshot of cardiovascular physiology which may not meet the needs of critically ill infants. In contrast, hemodynamic-based echocardiography can identify cardiovascular compromise, change management, longitudinally assess the response to therapeutic interventions and influence short term outcomes. In 2011, ASE published practice guidelines highlighting the scope of the field, the importance of rigorous training and collaboration with Pediatric Cardiology.[1] Neonatal Hemodynamics is the integration of imaging skills, and echocardiographic measurements with physiology and pharmacology alongside critical care and the development of novel research insights, all aimed to provide precision care to patients and families (*Figure 1*).

With the growth of the field of Neonatal Hemodynamics, there has been a resultant increase in those interested in obtaining advanced training in Neonatal Hemodynamic programs. We here-

Hemodynamic-based echocardiography can identify cardiovascular compromise, change management, longitudinally assess the response to therapeutic interventions and influence short term outcomes.

by present the perspectives of recent graduates of North American and European Neonatal Hemodynamics training programs, their individual rationales for taking on additional advance training, the realities of completing a formalized fellowship/training program, and key lessons learned during this additional year of training.

The North American Perspective

Rationale for taking on additional training:
The use of echocardiography by neonatologists with hemodynamic expertise offers clinicians caring for neonates and infants the opportunity to provide individualized, physiology-centered precision care. For Drs. Amy Stanford, Faith Zhu, and Adrianne Bischoff, witnessing the use of targeted neonatal echocardiography (TnECHO) in the management of acutely unwell neonates in their respective neonatal intensive care units (NICUs) in North America was the motivation behind their decision to undergo additional training in Neonatal Hemodynamics. All three completed neonatology fellowship prior to pursuing a fellowship in Neonatal Hemodynamics.

The realities of completing a training program:
The Neonatal Hemodynamics program in Toronto is an accredited training program in Canada offered to individuals who have completed Neonatal-Perinatal training and is one of several existing programs in Canada. In 2019, the first Neonatal Hemodynamics training program in the United States was launched at the University of Iowa with a similar model to the ones in Canada. Both Toronto and Iowa offer a one-year TnECHO fellowship which includes formal training in acquisition of echocardiography images with additional key education into cardiovascular physiology and integration of these skills and knowledge with NICU pathologies. The goal of these fellowship programs is to train individuals to be proficient in Neonatal Hemodynamics and to be able to support colleagues using these additional skills to provide clinical recommendations for infants in the NICU.

Dr. Adrianne Bischoff experienced the expert consultant model of Neonatal Hemodynamics during her Neonatal-Perinatal Medicine fellowship training at the Hospital for Sick Children in Toronto. It quickly became apparent the importance of the field in providing precision in

Dr. Adrianne Bischoff

Figure 1: Key aspects of Neonatal Hemodynamics training.

DEGREE OF DIFFICULTY OF THE LEARNING CURVE FOR NEONATAL HEMODYNAMICS FELLOW

Imaging Competencies

- **Physics** of ultrasound
- Identifying **normal structures**
- Probe selection
- **Knobology** [on each US machine]
- Image quality optimization
- Learning "**optimal views**"
- Mechanics of holding a probe
- Keeping location fixed on a baby
- **Optimizing 2D views**
- Color gain, scale, position
- **Doppler orientation, position**, scale
- Tissue Doppler imaging
- Measurements to minimize operator variability [intra- and inter-]
- Imaging speed
- Noticing "incidentalomas" and adding imaging when needed
- **Congenital heart disease red flags**

Cognitive Competencies

- **Interpretation of measurements**
- Understanding measurement **strengths and limitations**
- Assumptions of ultrasound, measurements and 2D into 3D
- Physiological **pattern recognition**
- **Normal physiological variation** by GA and PMA [transition, convalescence]
- Disease **pathophysiology**
- **Interaction** of intensive care strategies [fluid, ventilation, etc]
- Drug **mechanisms, pharmacology**
- **Natural history** of diseases, therapies
- Problem solving in low-frequency, high-risk situations
- "Emergent", "urgent", "elective" need to communicate findings
- When to **call cardiology** and how emergently

Professionalism Competencies

- Infection control
- Minimizing **patient discomfort** [varies by GA, PMA, condition]
- Communication to parents to ensure comfort with competency but not undermine clinical team
- **Communication with clinical team** of physiology and recommendations [what is "enough" data varies by LIP]
- Navigating providing "**plan changing information**" when unexpected
- Teaching without undermining primary caregivers
- Navigating **physiologic uncertainty**
- When to abridge a scan due to instability
- Handling codes/acute decompensation as a consultant
- **Moving on from making mistakes** as a consultant in life/death cases

the diagnosis and management of clinically unwell neonates. Adrianne was driven not only by the possibility of acquiring a skill which would aid in clinical care, but also by the possibilities related to research and innovations in the field. She engaged in clinical research during NICU fellowship under the guidance of Drs. McNamara and Giesinger and pursued formal neonatal hemodynamics training subsequently. Adrianne was the first neonatal hemodynamics trainee in a university accredited hemodynamics fellowship in the United States. During her training she not only acquired the skillset to apply the hemodynamic knowledge into clinical practice, but also conducted echocardiography-based research that is guiding her into generating novel ideas and questions. Adrianne completed her one-year fellowship at the University of Iowa, and subsequently joined the faculty of neonatology where she has since contributed as first author in several research projects actively engaged in the training of subsequent fellows and trainees.

Dr. Amy Stanford

Dr. Amy Stanford was first exposed to the field of Neonatal Hemodynamics in 2018 during her second year of Neonatology fellowship at the University of Iowa. For Amy, the need to obtain advance training became very apparent during Drs. McNamara and Giesingers' first year at Iowa, when a seminal case solidified her desire. A former extremely low birth weight infant developed concern for necrotizing enterocolitis at one month of age. The infant was on maximal doses of multiple inotropes and vasopressors with worsening clinical status as the family was counseled that survival would be unlikely. Within two hours of the TnECHO and neonatal hemodynamics consultation and the care individualized to the patient's hemodynamic state, only one cardiotropic medication remained with normalization of blood pressure, weaning of oxygen support, and resolution of low poor cardiac output and lactic acidosis. The impact of the neonatal hemodynamics consultation on that patient was life saving. Amy saw firsthand how being able to provide targeted, precise, physiology-based management with serial assessments allowed the team at Iowa to adjust treatment plans accordingly and improve short-term outcomes. Amy completed her training and was the second fellow to graduate from the University of Iowa Neonatal Hemodynamics Fellowship, in 2021. Like Adrianne, she joined as a faculty member within the Neonatal Hemodynamics program at Iowa. Amy has contributed to several research projects with one first author research paper and presented at national and international conferences. Most importantly, she found her passion for chronic pulmonary hypertension and is developing an Outpatient Hemodynamic Clinic in collaboration with pediatric cardiology and pulmonology. During her training, Amy recognized that it is increasingly clear that the contributors to cardiopulmonary disease among convalescing extremely preterm infants as they reach term and post-term postmenstrual age are complex. Systemic and pulmonary hypertension and pulmonary vein disease may have similar clinical presentations but require therapies which are not only different, but also potentially harmful if the diagnosis is not accurate. In collaboration with the Lung Rehabilitation Team, Amy is shepherding the development of an enhanced focus in this area, and this clinic is the first of its kind in the world and seeks to become a multidisciplinary clinic with the intent of continuing to improve the long-term outcomes of its premature survivors.

Dr. Faith Zhu

Dr. Faith Zhu moved from the United Kingdom to Toronto in 2018 to join the University of Toronto's Neonatal-Perinatal Medicine program. She started her journey into Neonatal Hemodynamics training through conducting hemodynamics research in the first year of her Neonatal-Perinatal fellowship. She later obtained a third-year research fellowship where she underwent formal Neonatal Hemodynamics training which allowed her to consolidate her research training with clinical hemodynamics. For Faith, understanding and incorporating cardiac physiology at the bedside to alter the management of acutely unwell infants has been one of the most rewarding clinical experiences. Faith was fortunate to be mentored by Dr. Amish Jain at Mount Sinai Hospital and Dr. Dany Weisz at Sunnybrook Hospital, both of whom are leaders in the field of Neonatal Hemodynamic research. She has completed three first-author research projects and had the opportunity to present her research in national and international conferences. Faith will start as an attending neonatologist at Mount Sinai Hospital, Toronto, in the clinician scientist training program where she will continue to help training future Neonatal Hemodynamics trainees. Using the skills and knowledge that she has acquired, her aim is to develop a research program focus on gastrointestinal and vascular hemodynamics by understanding its interaction with systemic hemodynamics and its relationship to NICU interventions.

Key lessons learned during this additional year of training:

Drs. Stanford, Bischoff, and Zhu have reflected on their year of training and a number of shared key lessons. First, the importance of precision – this ranged from being precise in image acquisition to the definition of the underlying pathophysiology and understanding of the interventions that are used in the NICU. The ability to being precise in these moments can accurately inform the management plan of a patient and impact their outcomes. Second, to constantly question why and to reassess the situation especially when there is an unexpected outcome. They learned to strive to seek answers to provide the best patient care while also identifying knowledge gaps that exist to generate future research questions. Third, identification of mentorship has been instrumental in shaping career paths. Amy, Faith, and Adrianne highly value the guidance from their respective mentors in developing their critical thinking and methodical approach to neonatal hemodynamic management.

The European Perspective:

Rationale for taking on additional advanced training:

The European Consensus for neonatologist performed echocardiography states "there is some evidence that routine use of echocardiography on the neonatal unit might lead to early identification of cardiovascular compromise that could facilitate clinical management, potentially improving short-term outcomes".[2] This statement embodies the rationale for taking on additional advanced training for both Drs. Neidin Bussmann and Tim Hundschied. This novel skill is not compulsory in the Irish Neonatal Higher Specialist Training Program nor within the subspeciality of Neonatology in the Dutch Society of Paediatrics. Both Neidin and Tim decided early in their training in pediatrics to actively pursue the avenue of Neonatal Hemodynamics to positively enhance their clinical and research-focused role in the Neonatal Intensive Care Unit.

The realities of completing a training program:

Training to become a neonatologist with a specialist interest in Neonatal Hemodynamics in Ireland, as well as in the Netherlands, is a convoluted journey. In short, a formal Neonatal Hemodynamics training program does not yet exist. In fact, in Ireland, the Neonatal Higher Specialist Training Program is itself in its infancy, and Neidin was one of four candidates who successfully entered the program in its first year in 2017. Prior to this, Neidin had completed an internship in General Medicine and Surgery in Beaumont Hospital, Dublin and Our Lady of Lourdes, Drogheda in 2012. Neidin went on to complete Basic Specialist Training in Pediatrics and acquired paediatric membership examinations with the Royal College of Physicians in Ireland in 2015. Neidin commenced the Pediatric Higher Specialist Training Program in 2015 and then subspecialised in Neonatology from 2017. Four and a half years later, Neidin was awarded the Certificate of Completion of Subspecialist Training in Neonatology.

Dr. Neidin Bussmann

As there are no formalized pathways or training programs for Neonatal Hemodynamics currently available in Ireland, and Neidin was keen to stay in Ireland to continue her training, she was required to search for a mentor in this field and take time out of clinical practice to pursue additional advanced training. She was fortunate to have had the opportunity to undertake research in the Rotunda Hospital, Dublin under Dr. Afif EL-Khuffash who is a world leader in neonatal hemodynamics research. In November 2020, Neidin was awarded a Doctor of Philosophy (PhD) through the Royal College of Surgeons Ireland for her thesis entitled "A Randomised Controlled Trial of Early Targeted Patent Ductus Arteriosus Treatment Using a Risk Based Severity

Score (The PDA RCT)." During her research years she became proficient in Neonatal Hemodynamics under the mentorship of Dr. El-Khuffash.

Dr. Tim Hundscheid started his research during his training in pediatric medicine, which was integrated into his specialist training program in the Netherlands. During Tim's PhD on the BeNeDuctus trial – a randomized controlled trial of expectant versus early pharmacological PDA management in extreme preterm infants – he became interested in the additional value of NPE not only for the assessment of a PDA but also in managing neonatal shock and supporting central line placement. Tim had the opportunity to learn the basics in echocardiography using a state-of-the-art echocardiography simulator and advanced to clinical bedside echocardiography in conjunction with the pediatric cardiology department at the end of his specialist training in Pediatrics. Tim trained under the guidance of Dr. Willem de Boode, former secretary of the section Circulation, Oxygen Transport & Haematology within the European Society for Paediatric Research (ESPR). He initiated the special interest group NPE within ESPR that published a series of state-of-the-art NPE review papers in a supplement in Pediatric Research. Tim is currently a fellow in neonatology and offers support to his clinical colleagues in decision-making by performing hemodynamic assessments at the bedside.

Dr. Tim Hundschied

Key lessons learned during this additional year of training:

The importance of choosing a supportive mentor was considered the top priority for each trainee. Neidin stressed the importance of working with a mentor who will not only devote a significant amount of time for the initial training, but also protect the trainees time and interests to allow for sufficient growth and development. Dr. El-Khuffash developed a rigorous training program that incorporated clinical and research competencies allowing her to complete her PhD, present her research nationally and internationally, publish in peer reviewed journals, and win multiple prestigious awards for the work. Dr. El-Khuffash introduced her to the nuances of Neonatal Hemodynamics, and she now endeavors to continue nurturing this skill in her new role as Consultant Neonatologist in Cork University Maternity Hospital. Tim is very thankful to Dr. Willem de Boode for his invaluable support and enthusiasm, as well as the Pediatric cardiology department for their support and collaboration in his training. With the lessons learned during his training, the aim is to facilitate a formalized Neonatologist Performed Echocardiography program in the Radboudumc Amalia Children's Hospital in the near future. Currently, the ESPR is working on the establishment of a pan-European governance structure for training in and accreditation of NPE.

Conclusion

These trainees embarked on an additional training in Neonatal Hemodynamics with all of its challenges and complexities. Unlike the relatively seamless transition from Pediatrics residency to Neonatology fellowship, echo-focused training was completely novel and included learning of a new skill from scratch. The knowledge and skills to achieve competency in neonatal hemodynamics were far beyond echocardiographic acquisition and interpretation. These trainees acquired skills related to navigating the politics of practicing being a consultant within the specialty. They gained cognitive skills that are essential in the care of complex neonates and believe that they will continue to advance the field and inspire the next generation of trainees.

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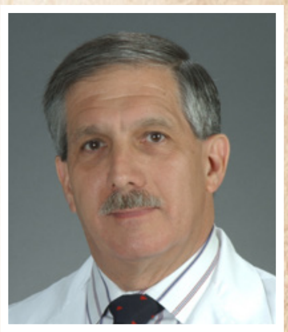
HOW DID Cardiac Sonographers BECOME Cardiac Sonographers?

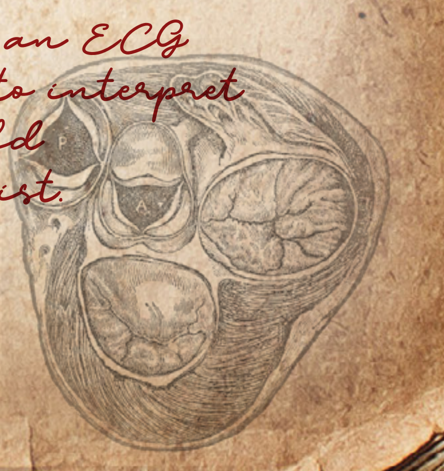
An article in last month's *Echo* magazine[1] focused on the early days of sonography in the United States. This discussion ended by noting that establishing a new profession included the need to develop appropriate programs for training practitioners, and professional standards that could be used to judge the trainees' skills.



Contributed by **Alan S. Pearlman, MD, FASE**, ASE Past President, and Editor-in-Chief, Emeritus, *Journal of the American Society of Echocardiography* (JASE)

In the 1970s, the field of echocardiography gained acceptance, clinical applications were documented and became part of the practice of cardiovascular medicine, and the value of skilled sonographers was increasingly evident. One obvious question is "how did cardiac sonographers acquire their skills?" My own recollection, augmented by very helpful input from a group of cardiac sonographers (see Acknowledgment below) who were early participants in the field, suggests some patterns. At first, there were no "training programs." I'm reminded of the rise of cardiovascular medicine as a clinical specialty. In his book "American Cardiology: The History of a Specialty and Its College," W. Bruce Fye MD, MACC, FASE, noted that in the early part of the 20th century, a physician who owned an ECG machine and knew how to interpret electrocardiograms could claim to be a cardiologist.[2] Cardiology fellowships did not exist, and a young physician who was intrigued by heart disease had no need to learn cardiac catheterization or echocardiography or nuclear cardiology or cardiac electrophysiology, because those techniques had not yet been invented!

> *A physician who owned an ECG machine and knew how to interpret electrocardiograms could claim to be a cardiologist.*



I believe that the pioneers in cardiac sonography found themselves in similar circumstances. They had no need to learn tomographic imaging planes or to master the principles underlying Doppler hemodynamics or myocardial strain analyses because those technologies did not yet exist. Instead, the enthusiastic young sonographer of the 1970s had to learn the basics of cardiac anatomy and the physical principles governing the application of reflected ultrasound. They also had to understand how controls on early ultrasonoscopes could be adjusted in order to optimize and record the information gathered. But where and from whom could they learn this information? While the options expanded and became more sophisticated as the field evolved, early on there were no formal training programs. The “teachers” were often relatively junior physicians who themselves were learning the same skills. My own memories, and the recollections of a group of sonographers who could be considered among the “founders” of the profession, are concordant on this point. Physicians and sonographers often learned together, side-by-side, and they sometimes quarreled over who got to hold the transducer! This was particularly true when two-dimensional echo became a reality. As is even more the case today than 50 years ago, physicians had other clinical demands and did not always have the time needed to perform a careful and “complete” echo exam themselves. However, sonographers did not have those same clinical demands and were able to take the time to do a thorough and careful job. In Europe, where I worked for a year as a research fellow many years ago, physicians did their own scanning, and they focused on the clinical question(s) at hand. Their studies were often not comprehensive and not always optimized; once the clinical question had been addressed, the echo exam was over.

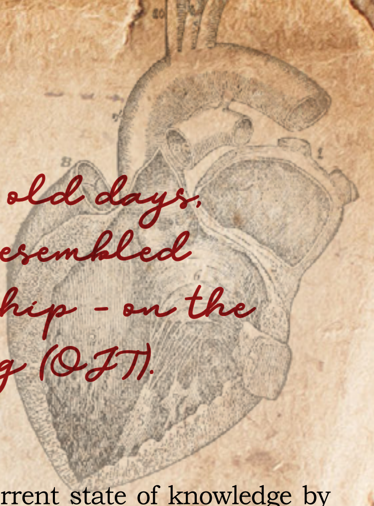
The enthusiastic young sonographer of the 1970s had to learn the basics of cardiac anatomy and the physical principles governing the application of reflected ultrasound.

Early in my own career, I remember getting together with our small group of sonographers and a few fellows in the late afternoon to go over all of the day’s cases in reading sessions that often lasted well beyond what today would be considered as “mandatory clock-out time.” I learned as much from the sonographers as they did from me, and we had a chance to discuss – as a group – cases, findings and their potential clinical implications, and technical issues. This was not only a great learning experience, but it also fostered collegiality, enhanced technical uniformity, and helped us all to understand our laboratory’s expectations. The small group of “founders” who graciously provided their own recollections described similar reading sessions in their laboratories, and they had similar memories of what we all fondly remember as the “good old days”. I could argue that clinical echocardiography has become the victim of its own success; the clinical workload has increased steadily, and clinicians are eager to know the results of testing – and will make management decisions based on those results – before the ECG electrodes have been removed from the patient! While not intending to sound bitter, I would observe that administrators seem to expect today’s cardiac sonographers to crank out a pre-determined number of studies, to download the images and measurements into the institution’s PACS system (Picture Archiving and Communications System), and to clock out in time to make the late afternoon bus. And … especially … to obviate the need for overtime pay! For many reasons, staying late to read echo studies with the docs is not an option. And I find this situation to be disappointing.

In the good old days, “training” resembled apprenticeship – on the job training (OJT). The focus of training was likely determined by the clinical and academic interests of the cardiologist(s) with whom one worked, and by the rapid expansion of the clinical settings in which echocardiographic findings were thought to be valuable. In some laboratories, M-mode echo remained the mainstay even after the introduction of cross-sectional, tomographic imaging. While today’s sonographers sometimes wonder “what’s the point of recording any M-mode,” the sonographers of yesteryear will remember thinking (and sometimes asking) “I just did a thorough M-mode exam – what’s the point of recording 2D images?” In some laboratories, Doppler was adopted early, while in others, the emphasis was on imaging – at least, until it became apparent that one could measure the pressure drop across stenotic valves using continuous wave Doppler.

How did the “founders” get involved in cardiac sonography when that discipline was in its infancy? Many of them came from “other” healthcare backgrounds but were intrigued by cardiac ultrasound. Some had worked as radiology techs but were eager to avoid radiation exposure. Some had worked as ECG or phonocardiography techs and found echocardiography to be more interesting, more exciting, and in some ways easier to understand. Some had clinical backgrounds, having worked as nurses, or as nursing assistants, or as medical corpsmen Let’s remember that in the 1970s, there was a mandatory draft, and for some bright young men, introduction to the medical field was a side benefit to their military service. Some had strong science backgrounds, and some were just eager to enter the new field of cardiac sonography.

At the start, someone interested in working as a cardiac sonographer would be lucky to find a (usually young) physician who was interested in this technique, looking for assistance, and willing to take the time to teach a sonographer. Eventually, however, different options for training evolved. Initially, a newcomer to the field might learn about the current state of knowledge by attending a weekend course. As the repository of information expanded, educational courses also grew in length – one month, three months, and eventually a full year, after which the trainee received a certificate documenting that they had completed a “training program.” Before long, more formal educational programs began to develop – usually affiliated with colleges and universities or with medical institutions. Sonography was considered – and continues to be considered – as an Allied Health Profession. Early on, formal educational programs in the Allied Health professions awarded their graduates a two-year Associate degree. Eventually Baccalaureate-level programs became the norm. Some of the early educational programs in cardiac ultrasound were based in San Diego, Oklahoma City, Philadelphia, and Seattle. Educational programs in cardiovascular technology, such as the one in Spokane, provided another approach to training in cardiac ultrasound.



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As noted previously,[1] professional organizations formed in order to represent the interests of practitioners of clinical ultrasound. These included the American Institute of Ultrasound in Medicine (AIUM), the American Society of Ultrasound Technical Specialists (ASUTS) – which evolved into the Society of Diagnostic Medical Sonographers (SDMS), the National Society of Cardiopulmonary Technologists (NSCPT), and the Society of Non-Invasive Vascular Technology (SNIVT) – which morphed into the Society of Vascular Ultrasound (SVU). As the field of what would become known as “sonography” grew, these organizations recognized the need for educational programs. Some professional organizations included educational programs as part of their annual meetings. Another mechanism for enhancing knowledge resulted from the needs of manufacturers of ultrasound equipment. They hired practicing sonographers to serve as "applications specialists" so that when a new user bought an ultrasound instrument, the manufacturer could provide not only the equipment but also instruction on how to use the controls, and how to locate, recognize, and record clinically relevant findings! In the 1980s, journals such as the Journal of Diagnostic Medical Sonography (JDMS) and the Journal for Vascular Ultrasound (JVU) were founded by the SDMS and the SVU, respectively; these were also helpful educational vehicles.

Several organizations recognized the need to develop a registry of practitioners who had taken – and passed – a registry exam documenting their skills. Two pathways are noteworthy. The NSCPT evolved to represent individuals practicing different aspects of "cardiovascular technology," including technical specialists who worked in laboratories performing cardiac cath, electrophysiology, ECG, vascular medicine, and echocardiography. The NSCPT began administering credentialing exams in 1968, initially focusing on cardiac cath; eventually other practice areas were included. Credentialing in a range of cardiovascular technologies is now offered under the auspices of Cardiovascular Credentialing International (CCI).

While some sonographers trained in cardiac ultrasound as part of a cardiovascular technology program, many sonographers trained in an ultrasound program.

While some sonographers trained in cardiac ultrasound as part of a cardiovascular technology program, many sonographers trained in an ultrasound program. The ASUTS began in 1969 as an organization representing technical specialists who used ultrasound in different clinical settings, including cardiology. The Examination Committee of the ASUTS evolved into an organization known as the ARDMS – the American Registry for Diagnostic Medical Sonography – which was incorporated in 1975. To persuade the Council on Medical Education of the American Medical Association (AMA) to recognize diagnostic sonography as a new profession, the ARDMS was tasked with documenting the responsibilities of and need for "technical specialists," writing a basic education syllabus, developing both written and practical examinations, and providing a mechanism to document skills in sonography. In the 1990s, a new agency known as CAAHEP, the Commission on Accreditation of Allied Health Education Programs, was founded and tasked with overseeing the accreditation of educational programs in the health sciences. Three committees on accreditation are particularly relevant to cardiac sonographers: the Joint Review Committee on Education in Cardiovascular Technology (JRC-CVT), the Joint Review Committee on Education in Diagnostic Medical Sonography (JRC-DMS), and the Committee on Accreditation for Advanced Cardiovascular Sonography (CoA-ACS). CAAHEP commissioners represent a large number of sponsoring organizations, reflecting the substantial range of health education professions. Readers of this magazine will recognize the American College of Cardiology, the American Society of Anesthesiologists, and the American College of Emergency

Physicians. Health professions less familiar to some readers include the American Art Therapy Association, the Association of Medical Illustrators, and the International Association of Fire Fighters. In addition to the committees on accreditation listed above, CAAHEP sponsors with a focus on cardiovascular sonography include the American Society of Echocardiography, the American College of Cardiology, the American Institute of Ultrasound in Medicine, the Society of Cardiovascular Anesthesiologists, the Society for Vascular Surgery, the Society for Vascular Ultrasound, and the Society of Diagnostic Medical Sonography.

Since the first "cardiac sonographers" picked up a transducer almost 60 years ago, the field of cardiac sonography has evolved tremendously. Starting with on the job "apprenticeship" training and a few prophetic educational programs, the field has grown dramatically. The next in this series of articles about the history of Cardiac Sonography will focus in more detail on the evolution of educational programs, and the expansion of career opportunities for cardiac sonographers. Stay tuned!

ACKNOWLEDGMENT

I wish to express my profound gratitude to a group of cardiac sonographers who have been involved in echocardiography for as long as I have been. These talented professionals have contributed to our field in too many ways to mention in this space, and their accomplishments have been recognized – publicly and appropriately – in other venues. I am grateful to them for sharing with me some recollections of their introductions to the field, and for their efforts to keep my own recollections "honest." Listed alphabetically, they include David Adams, Joan Baker, Carolyn Gardner, Sandy Hagen-Ansert, Kitty Kisslo, Oi Ling Kwan, Jane Marshall, and last – but certainly not least – Alan Waggoner. Thanks too to Merri Bremer and Carol Mitchell for their valuable comments.

Since the first "cardiac sonographers" picked up a transducer almost 60 years ago, the field of cardiac sonography has evolved tremendously.

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IMPORTANT GUIDANCE ON CPT CODE +93319

The AMA CPT published a new add on CPT code +93319 for CY2022. As part of the discussion during the CPT Panel meeting, there were multiple stakeholders who provided suggested edits and modifications as part of the review process. The outcome from the AMA CPT Panel was to establish a new add-on code which must be utilized with a base echocardiography code: Congenital Transthoracic (CPT codes 93303, 93304) or Transesophageal Echocardiography (CPT codes 93312, 93314, 93315, 93317). During the iterative process noted above, a third party included Color Doppler CPT code +93325 in the exclusionary parenthetical.

ASE worked in conjunction with the pediatric echocardiography community and ACC to request an editorial edit to remove +93325. Unfortunately, the Panel's interpretation of how Color Flow Doppler is utilized in the performance of +93319 placed in question the viability of this submission. While we have a different interpretation, it was concluded that there is not a viable path forward for changing to the code.

Under these circumstances, **ASE would like to share with you some code guidance**. To use this new add-on code and be reimbursed properly, you must list this new CPT code, +93319, in addition to the appropriate base echocardiography code: Congenital Transthoracic CPT codes 93303, 93304.

CODING TIP: CPT code +93319 must be utilized with a base echocardiography code: Congenital Transthoracic (CPT codes 93303, 93304) or Transesophageal Echocardiography (CPT codes 93312, 93314, 93315, 93317). CPT code +93319 should be appended when 3D imaging is provided during the imaging capture portion of the congenital study. If 3D rendering with image interpretation and image post-processing is performed post image capture, then utilize CPT codes 76376 and 76377.

NOTE: CY2022 Physician Work RVU for each service is:

93303 – 1.30
93325 – 0.07
+93319 – 0.50
76376 – 0.20
76377 – 0.79

Practical Points for ECHOCARDIOGRAPHY IN CARDIAC AMYLOIDOSIS

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OBJECTIVE This document was created by an American Society of Echocardiography Amyloidosis Task Force as a practical accompaniment to the recently published multisociety Expert Consensus Recommendations for Multimodality Imaging in Cardiac Amyloidosis.[1,2] In this document we will outline the common echocardiographic imaging findings of cardiac amyloidosis (CA), highlighting red flags that should raise suspicion for the diagnosis. We will also provide tips for image acquisition and interpretation. Based on the comprehensive multisociety document on imaging of CA,[1,2] this document will also provide recommendations for standard reporting of an echocardiogram in a patient with CA.

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WHAT IS CA?

Cardiac amyloidosis is a form of infiltrative cardiomyopathy due to deposition of amyloid fibrils in the myocardium.[3]

Most cases of CA result from 2 protein precursors (*Figure 1*):

- Monoclonal immunoglobulin light chain amyloidosis (AL) produced by bone marrow plasma cells
- Transthyretin (TTR), a serum transport protein for thyroid hormone and retinol that is synthesized primarily by the liver. The resulting amyloid TTR (ATTR) amyloidosis is further subtyped into wild-type (wtATTR) or hereditary/variant (vATTR), the latter resulting from genetic variants in the TTR gene.

Systemic AL amyloidosis is a rare disease with an incidence of less than 50 cases per million person-years, with equal distribution between sexes. The disease generally presents from the fifth to seventh decade, although it may occur at all ages from the fourth decade onward. Wild-type ATTR CA is more common, with a prevalence as high as 10% in older patients with increased wall thickness and heart failure with preserved ejection fraction and up to 16% in older patients with aortic stenosis (AS).[4-7] One of the most common mutations associated with vATTR amyloid is V142I (legacy nomenclature, V122I), which has been reproducibly demonstrated in 3.4% of African Americans, with a lower penetrance.[8]

There is significant heterogeneity in clinical course, prognosis, and treatment approach between AL and ATTR; however, echocardiographic features are similar.

Cardiac involvement leads to atrial arrhythmias, conduction system disease, and progressive heart failure. Echocardiography is commonly one of the first investigations to raise the suspicion for CA, where early and successful diagnosis is dependent on the awareness of the sonographer and reader of the cardinal features of the disease. As the efficacy of newer therapeutics are dependent on early diagnosis, it has never been more vital for the imaging team to be aware of these features.

ABBREVIATIONS

2D = Two-dimensional
AL = Light chain amyloidosis
AS = Aortic stenosis
ATTR = Transthyretin amyloidosis
CA = Cardiac amyloidosis
ECG = Electrocardiogram
EF = Ejection fraction
GLS = Global longitudinal strain
IVS = Interventricular septum
LA = Left atrium
LV = Left ventricle, ventricular
LVEF = Left ventricular ejection fraction
ROI = Region of interest
RRSR = Relative regional strain ratio
RV = Right ventricle, ventricular
vATTR = Variant ATTR
wtATTR = Wild-type ATTR

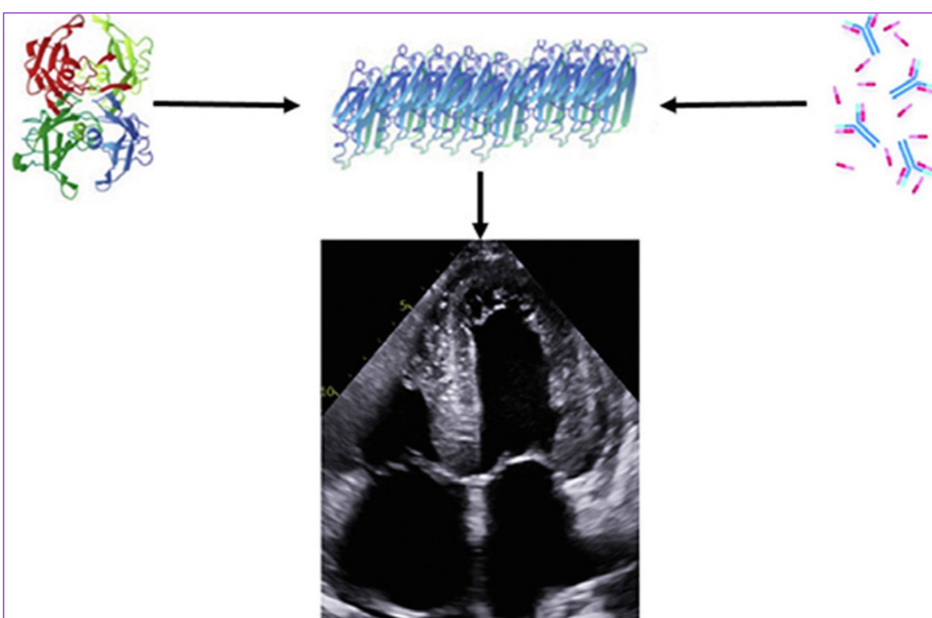

FIGURE 1 Pathogenesis of CA. This schematic shows the 2 main precursor proteins associated with cardiac infiltration in amyloidosis. Transthyretin (left panel) or abnormal light chains (right panel) produced by the plasma cells misfold, aggregate, and form amyloid fibrils that deposit in the extracellular space. Both types have a similar appearance when stained with Congo red; immunofluorescence and/or mass spectrometry are/is required to distinguish the type of precursor protein. Similarly, no echocardiographic features distinguish the type of amyloid infiltration.

ECHOCARDIOGRAPHY OVERVIEW

Echocardiography plays a major role in the noninvasive evaluation of CA. The advantages of this imaging modality are safety, availability, portability, relatively low cost, and ability to provide hemodynamic and diastolic function assessments. While echocardiography is not sufficient by itself to definitively diagnose and differentiate the type of CA (AL vs ATTR), it is an essential part of the diagnostic, prognostic, and ongoing management of patients with this disorder.

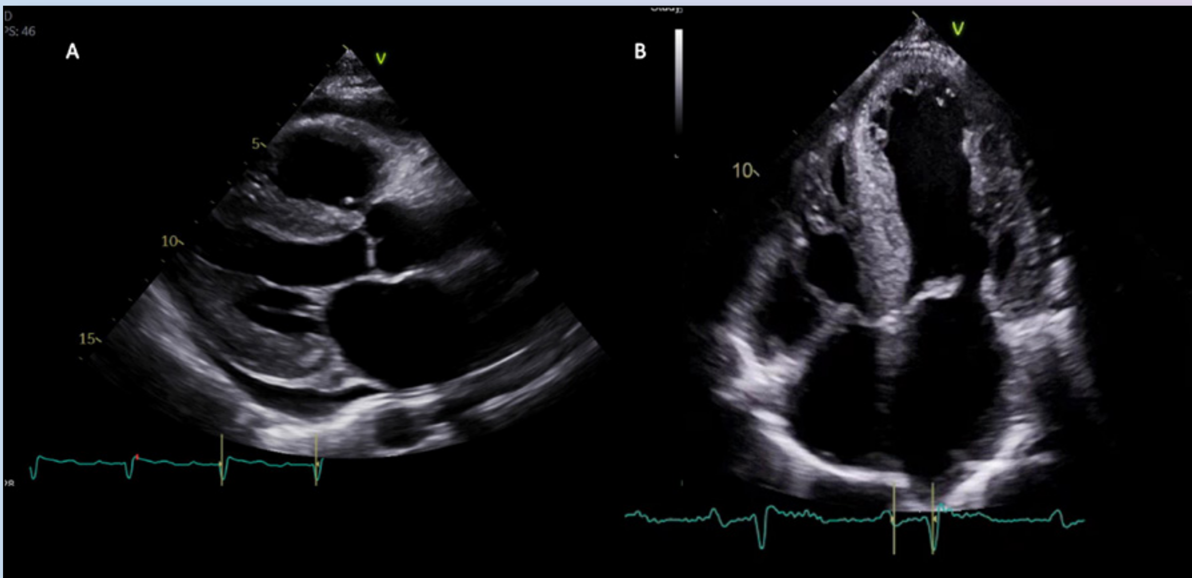

FIGURE 2 Typical echocardiographic findings. (A) Parasternal long-axis view: the ventricular wall thickness is increased, there is atrial dilation, and a small pericardial effusion is seen. (B) Apical 4-chamber view. Increased biventricular wall thickness, biatrial dilation, and valvular thickening are shown.

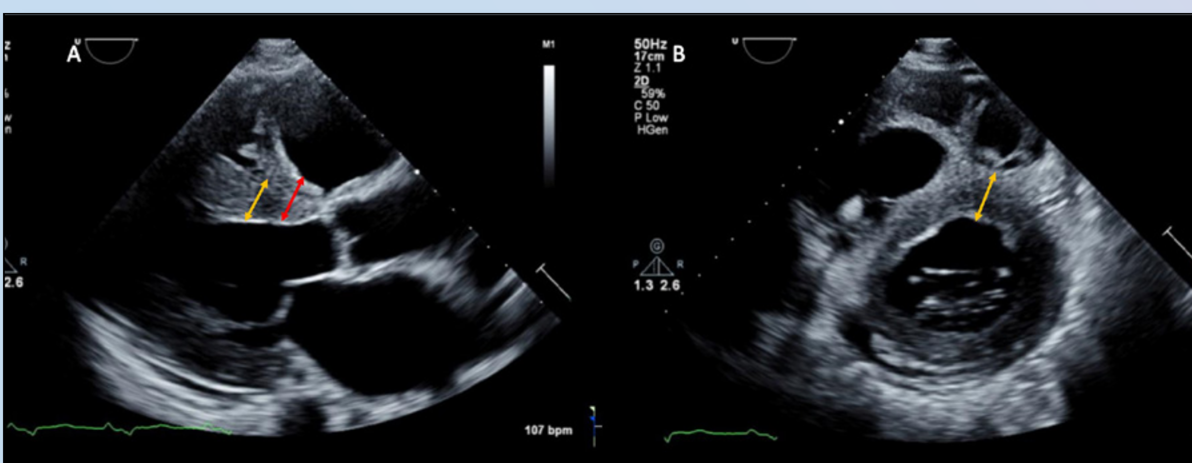

FIGURE 3 Erroneous IVS wall measurement (red arrow). The IVS thickness is measured in the parasternal long-axis view (A). If there is uncertainty, the wall thickness should be verified in the short-axis view (B), ensuring RV structures are not included in the IVS measurement. Correct measurements are shown with the orange arrow.

RED FLAGS (COMMON FEATURES ON IMAGING)

There are several typical morphologic and functional features of CA that should raise suspicion, so-called red flags (*Figure 2*):

- Increased left ventricular (LV) and right ventricular (RV) wall thickening
- Biatrial enlargement
- Increased LV wall thickness with low-voltage criteria on associated electrocardiogram (ECG)
- Diastolic dysfunction (≥grade II) with elevated LV filling pressures
- Severely reduced mitral annular tissue Doppler velocities
- Reduced global longitudinal strain (GLS) with apical sparing
- Low-flow, low-gradient AS, paradoxical rather than classical
- Pericardial effusion
- Increased atrial septal thickness
- Diffuse valve thickening
- Preserved ejection fraction with low stroke volume index

When these features are present in certain patient populations, CA should be considered as the possible underlying etiology (*Table 1*).

TABLE 1 At-risk populations where CA should be considered

At-risk populations	Type (most likely)*
Monoclonal gammopathy, multiple myeloma, or known extra cardiac amyloid	AL
Unexplained heart failure with hepatomegaly, macroglossia, periorbital purpura	AL
Heart failure and unexplained peripheral sensorimotor neuropathy	vATTR or AL
Non–African American individuals, with unexplained heart failure and increased wall thickness (not explained by hypertensive heart disease or other conditions)	AL, wtATTR, non-V142I vATTR
Men >50 years, with bilateral carpal tunnel syndrome† /biceps tendon rupture/spinal stenosis	wtATTR
African American individuals, ages >60 years, with increased wall thickness and/or unexplained heart failure	vATTR
ATTR genetic variant carrier	vATTR
Age >60 years with low-flow, low-gradient AS and increased wall thickness	wtATTR

The most likely amyloid type is indicated, but definitive tissue typing is required. Light chain amyloidosis always requires cardiac or noncardiac tissue; nuclear scintigraphy may be used in the proper clinical context if AL is excluded.
† Carpal tunnel syndrome, especially bilateral, may be present with any type of amyloid.

Tips for Assessing Cardiac Structure

All two-dimensional (2D) and Doppler echocardiographic acquisition and measurements in patients with suspected or known CA should follow the American Society of Echocardiography/European Association of Cardiovascular Imaging chamber quantification guidelines.[9,10]

Interventricular septum (IVS) measurement: this can be challenging due to RV structures including trabeculations, crista supraventricularis, and the moderator band. Wall thickness may be verified in the parasternal short-axis view (*Figure 3*).

Right ventricular wall measurement: RV wall thickness is best evaluated from the subcostal window with zoomed focus on the right ventricle (RV). Two-dimensional or M-mode echocardiographic measurements should be taken at end diastole. The measurement should be obtained ~ 1 cm below the tricuspid annulus at the level of the anterior tricuspid leaflet tip when the valve is fully open. Using breathing techniques and a zoomed view on the RV can help optimize this measurement (*Figure 4*).

Left atrial (LA) measurement: LA foreshortening is a common issue encountered in the standard apical views, focusing on the LV. Dedicated LA views, which demonstrate the full length of the atrium, should be acquired in the apical 4-chamber and 2-chamber views (*Figure 5*).

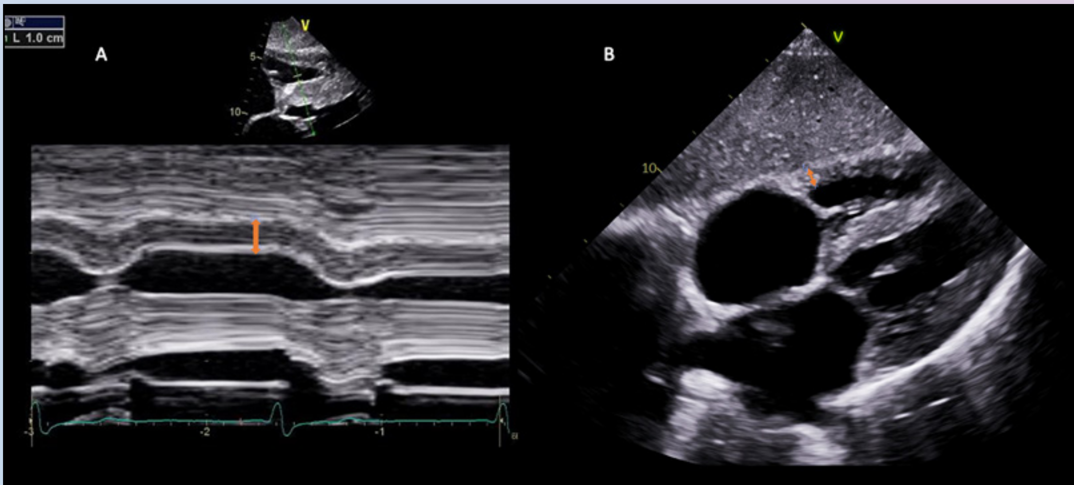

FIGURE 4 (A) M-mode echocardiography is used in the subcostal 4-chamber view to measure the RV free wall thickness. (B) Two-dimensional RV wall thickness measurement in the subcostal 4-chamber view. Correct measurements are shown with the orange arrow.

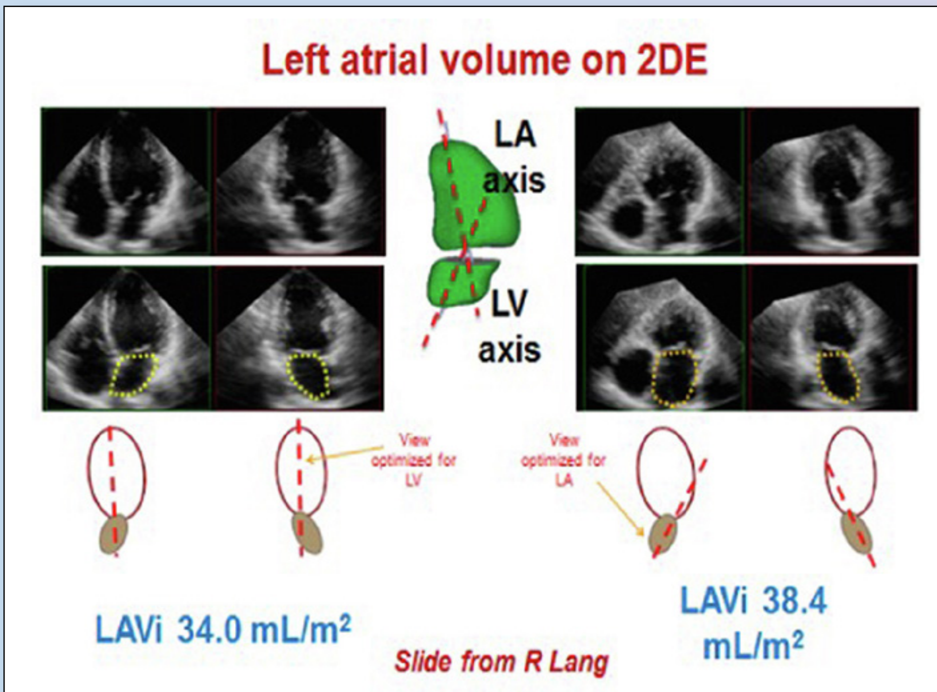

FIGURE 5 Left atrial foreshortening (R Lang slide). Nonforeshortened LA imaging is not always in the same plane as for the LV. Care should be taken to obtain focused on-axis views that include the left atrium (LA) at its maximal size while visualizing the pulmonary veins. Zoomed views of the LA can help define atrial borders. In cardiac amyloid, the LA is often dilated, and accurate volumes must be obtained to help with diagnosis. LAVi, LA volume indexed. Slide courtesy of Dr. Roberto Lang.

DOPPLER ECHOCARDIOGRAPHIC FEATURES IN CARDIAC AMYLOIDOSIS

Infiltration of amyloid fibrils in the myocardium results in abnormal LV relaxation and progressive diastolic dysfunction. The degree of diastolic dysfunction is often a reflection of the disease course, with more severe forms of dysfunction manifesting later in the disease.

The following Doppler indices are recommended to assess diastolic function and LA pressures *(Figure 6)*:

1. Pulsed-wave Doppler of mitral inflow: while grade I diastolic dysfunction may be present early in the course of disease, most patients demonstrate grade II or III diastolic dysfunction by the time the disease is detected.
2. Tissue Doppler of the mitral annulus: septal and lateral annular velocities are often very low (~ 5 cm/sec), reflecting abnormal myocardial relaxation and compliance.
3. Pulsed-wave Doppler of the pulmonary veins: pulmonary vein velocities reflect LV diastolic

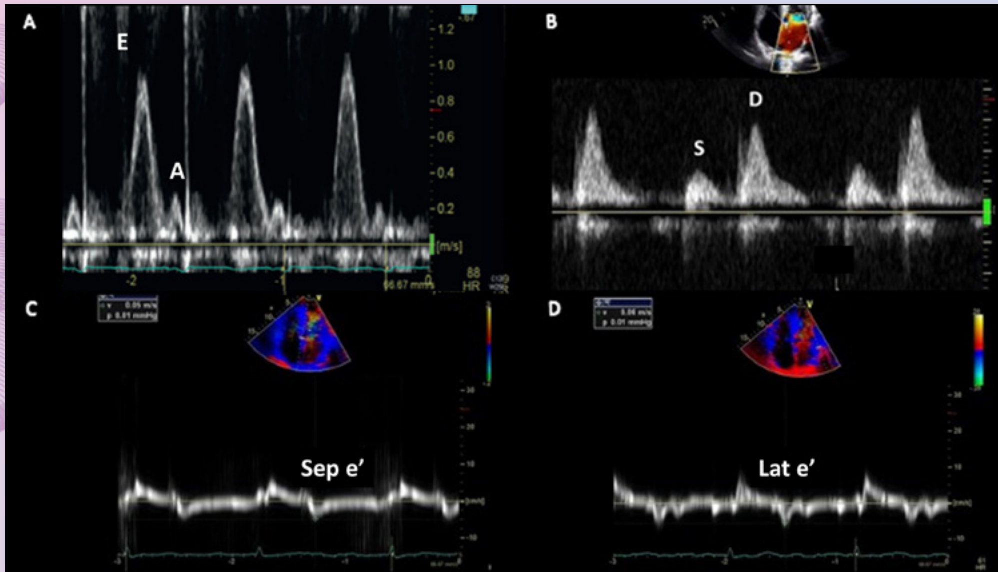

FIGURE 6 Typical Doppler velocity waveforms in amyloidosis. (A) Mitral inflow demonstrates a high E-wave velocity with a small A-wave velocity, E/A >2, and short deceleration time of 100 msec. (B) Pulmonary vein velocities exhibit systolic (S) blunting. Mitral annular tissue Doppler imaging velocities at the septal (C) and lateral (D) aspects of the annulus are reduced, leading to an average E/e' >14. Sep e'= septal e' velocity, Lat e'= lateral e' velocity.

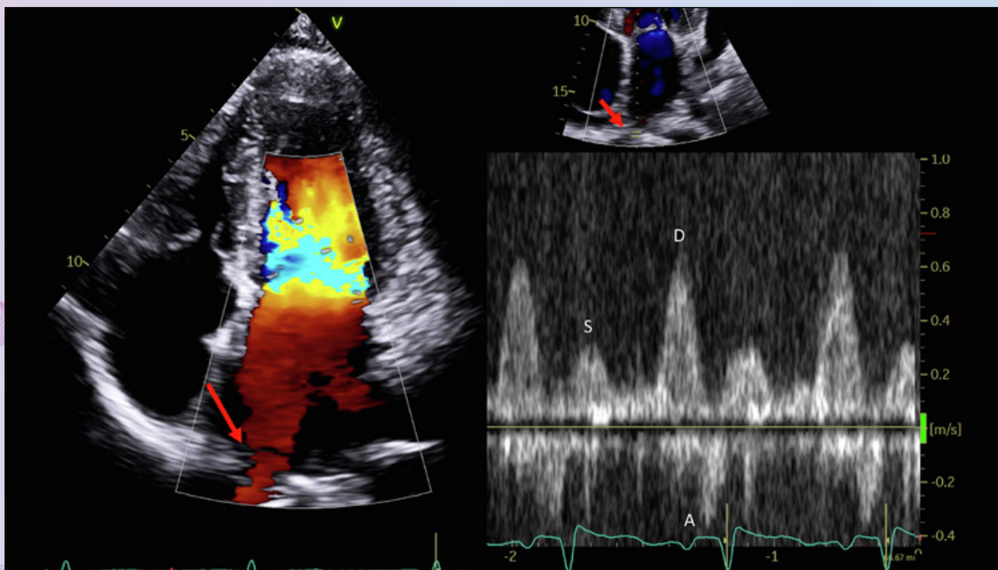

FIGURE 7 Color and spectral Doppler echocardiography of pulmonary vein (PV; red arrow). As shown in the top image, it is important to place the sample volume 1-2 mm into the PV. The pulsed-wave Doppler waveform shows a blunted systolic inflow (S), with higher velocity diastolic flow (D) and marked atrial reversal (A).

dysfunction and atriopathy, with a progressive decline in the pulmonary S wave (due to elevated LA pressure) and concurrent increase in the D wave with disease progression. An increased pulmonary vein atrial reversal velocity, reflecting increased LV end-diastolic pressure, may be seen (*Figure* 7).

Tips for Appropriate Doppler Techniques

Pulsed-wave Doppler assessment of mitral valve inflow is imperative for evaluating diastolic function. Sample volume size (optimally 1-3 mm) can affect the appearance of the waveform. Correct positioning of the sample volume is also crucial; the sample volume should be placed at the leaflet tips (*Video 1*). Placing the sample volume too far into the left ventricle (LV) can underestimate the E and A velocities and cause the modal velocity to be ill-defined.

Accurate tissue Doppler velocities are important when evaluating CA. Common pitfalls include small sample volume size (5-10 mm is the suggested sample size), incorrect sample volume position (correct placement should be just on the ventricular side of the annulus in the basal myocardium), poor Doppler alignment (the cursor should be aligned with the axis of movement of the annular plane), and variability with breathing (recording at end expiration is recommended; *Video* 2).

LV FUNCTION AND 2D SPECKLE-TRACKING IN CARDIAC AMYLOIDOSIS

Amyloid fibril infiltration impairs myocardial function, often with a normal appearing LV ejection fraction (LVEF). As the disease progresses the LVEF decreases. A midrange or even severely reduced LVEF may be present in vATTR, especially due to V142I mutation.

Two-dimensional speckle-tracking imaging is used to measure myocardial deformation. Global longitudinal strain is useful for diagnosing and quantifying myocardial dysfunction in CA. When it is abnormal, it reflects contractile dysfunction.

Measures of LV Strain

Global longitudinal strain: GLS is a unitless measure of longitudinal deformation with more negative values denoting greater deformation or more pronounced shortening. Therefore, values nearing 0% indicate akinesis, positive values indicate dyskinesis, and negative values indicate shortening/contraction. Normal values of GLS vary between vendors; normal is usually considered to be more negative than −20% with an SD of ± 2% (lower limit of normal −16% to −18%, depending on vendor; *Figure 8*).

Apical sparing: while there is a normal base-to-apex gradient in GLS, this has been found to be far more pronounced in CA. In CA, the apical segmental strain values are greater than those in the basal and middle segments. When plotted on a bull's-eye map, this will generate a characteristic "apical-sparing" pattern *(Figure 9)*.[11]

GLS Ratios

The original description of this regional variation in GLS seen in CA provided a ratio of apical strain to mid and basal strain (relative regional strain ratio [RRSR]), suggesting that this value was highly sensitive and specific for the diagnosis of CA compared to other causes of increased LV wall thickness when assessed in selected populations with increased wall thickness.11 Since that time, other ratios have been suggested for the diagnosis of CA. The septal apical-to-basal (SAB) ratio uses the 4-chamber septal apical and basal segmental longitudinal strain values.[12] The ejection fraction-to-strain ratio uses the discrepancy between the 2D LV systolic ejection fraction and the strain value that can be seen in CA.[13] These ratios have not been validated as screening tools in larger populations. The variation across vendors in the discriminatory ability of the RRSR ratio has been demonstrated and is driven by differences in regional strain[14] *(Figure 9)*. The RRSR and SAB cutoffs quoted in Table 2 were developed using the same vendor software (EchoPAC Advanced Analysis Technologies; GE Medical Systems) in select populations with increased wall thickness. In addition, strain values may differ across layers of the LV such that longitudinal strain is highest at the endocardium and lowest at the epicardium, highlighting the importance of region of interest (ROI) location *(Figure 11, Video 3)*. There is also variability across vendors pertaining to calculation of GLS and default layer selected, varying from a full-thickness calculation to midmyocardial or endocardial. Using GLS ratios can improve specificity at the cost of reduced sensitivity over visual assessment *(Table 2)*. The key concept is to perform strain imaging in patients referred for possible amyloidosis or with echocardiographic red flags noted during the examination; this can be done by the sonographer during image acquisition or after the study. In patients with subtle or no wall thickening, abnormal GLS with an apical-sparing pattern may be the clue to the diagnosis. It is important to also consider concomitant pathologies that may affect the strain pattern, such as prior infarct or marked LV dyssynchrony *(Figure 10)*.

TABLE 2 Longitudinal strain ratios that have been described, with the diagnostic cutoffs used in the original publications: proposed ratios incorporating LV GLS for diagnosis of CA

Ratio		Cutoff
RRSR[9]	Average apical segment LS/average combined mid + basal segment LS	>1.0
SAB LS ratio[10]		>2.1
Ejection fraction to strain ratio[13]		>4.1

LS, Longitudinal strain.

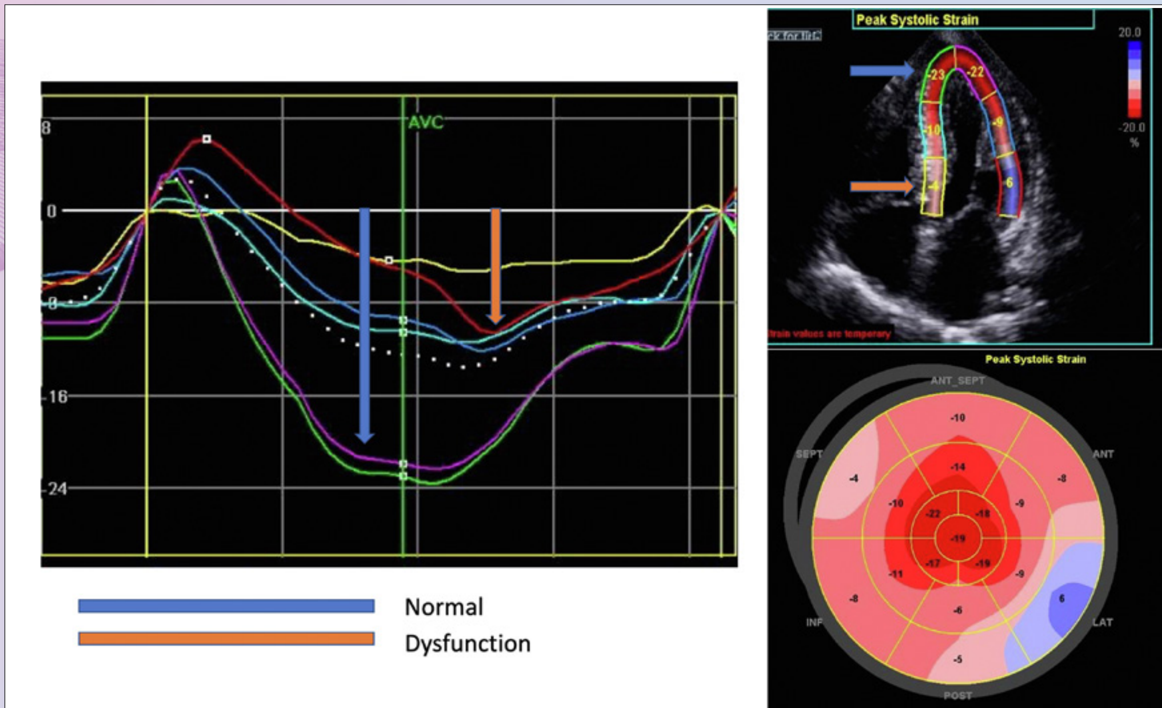

FIGURE 8 Typical apical-sparing longitudinal strain pattern, with time curves. The apical segments (blue arrow) are more preserved than the basal segments (orange arrow) assessed visually and quantitatively by the negative displacement from the 0 line. AVC, aortic valve closure.

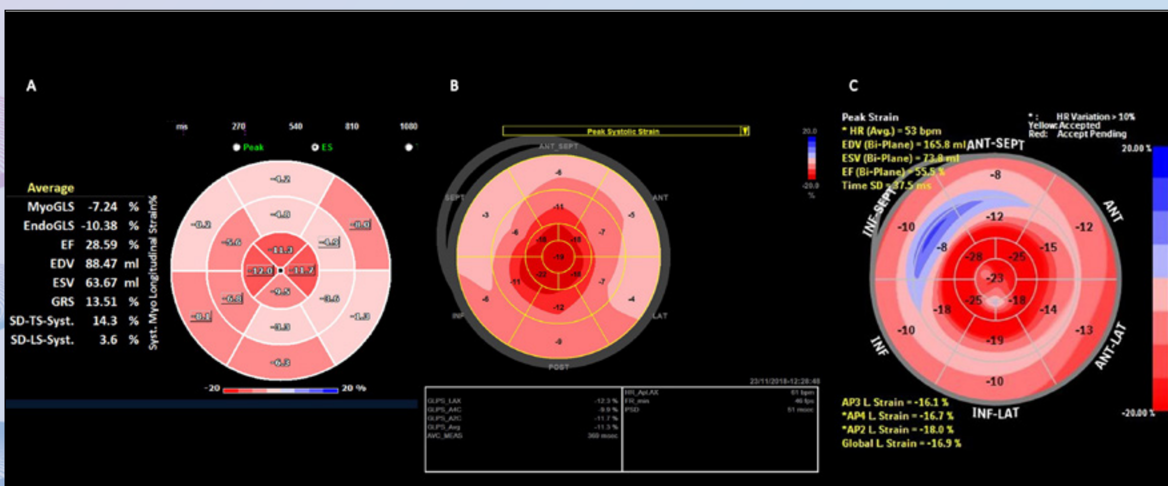

FIGURE 9 Variation across vendors. This figure shows the apical-sparing pattern of longitudinal strain for 3 different subjects using 3 different vendors: (A) TomTec, (B) GE EchoPAC, (C) Philips QLab.

TABLE 3 **Tips for performing strain analysis**

Parameter	Comment
Increased gain	Higher gain results in more speckles; need good endocardial definition.
Consistent sector width and depth	Wide enough to include the full wall thickness and apex and extend beyond annulus to allow capture of entire LV throughout cardiac cycle *(Video 3)*.
ROI	Include 90% of the myocardium as error can occur if too narrow, favoring epicardial or endocardial regions. If too wide can lead to abnormal values, often lower *(Video 4)*.
ECG gating and timing of end diastole and end systole to aortic valve opening and closing	It is very important for evaluation of end-systolic versus peak strain values; deformation after aortic valve closure is not relevant. If ECG gating is incorrect, e.g., tracking p wave, may need to manually adjust off-line *(Video 4)*.
Longitudinal follow-up	Consistent vendor *(Figure 9)*.

When to Seek Additional Information with Speckle-Tracking

Two-dimensional speckle-tracking with strain analysis should be performed in the following scenarios:

1. The study is suggestive of CA.
2. The clinical pretest probability is high (see Table 1 on at-risk populations).
3. There is undifferentiated LV wall thickening.

See the tips for strain analysis in *Table 3 (Figure 9, Figure 10, Figure 11, Videos 3 and 4)*.

REPORTING

The expert consensus document set out several features to note in the echocardiographic report *(Tables 4 and 5)*.[1,2] Raising the differential diagnosis of CA is appropriate if suggestive features are present in an at-risk population.

Standardized reporting suggestions are as follows:

1. When findings are suspicious for CA, a statement should be included in the final impressions (not buried elsewhere in the report).
2. Suggested wording:
   a. Findings are strongly suggestive of CA/infiltrative cardiomyopathy.
   b. Findings are suggestive of possible CA/infiltrative cardiomyopathy.
   c. The following findings suggest possible CA: [free form].
   d. Findings are not suggestive of CA/infiltrative cardiomyopathy.
   e. Findings are equivocal for CA/infiltrative cardiomyopathy.

Specific wording regarding further evaluation for infiltrative cardiomyopathy will vary according to local availability and expertise. Echocardiographers are encouraged to consider standardized wording appropriate to their practice, including screening for monoclonal gammopathy (serum-free light chain assay, serum and urine protein electrophoresis with immunofixation) and consideration of nuclear cardiac scintigraphy, cardiac magnetic resonance imaging, and tissue biopsy, if clinically indicated. Depending on institutional practice and resources, links to a diagnostic algorithm and specific testing order sets may be helpful.

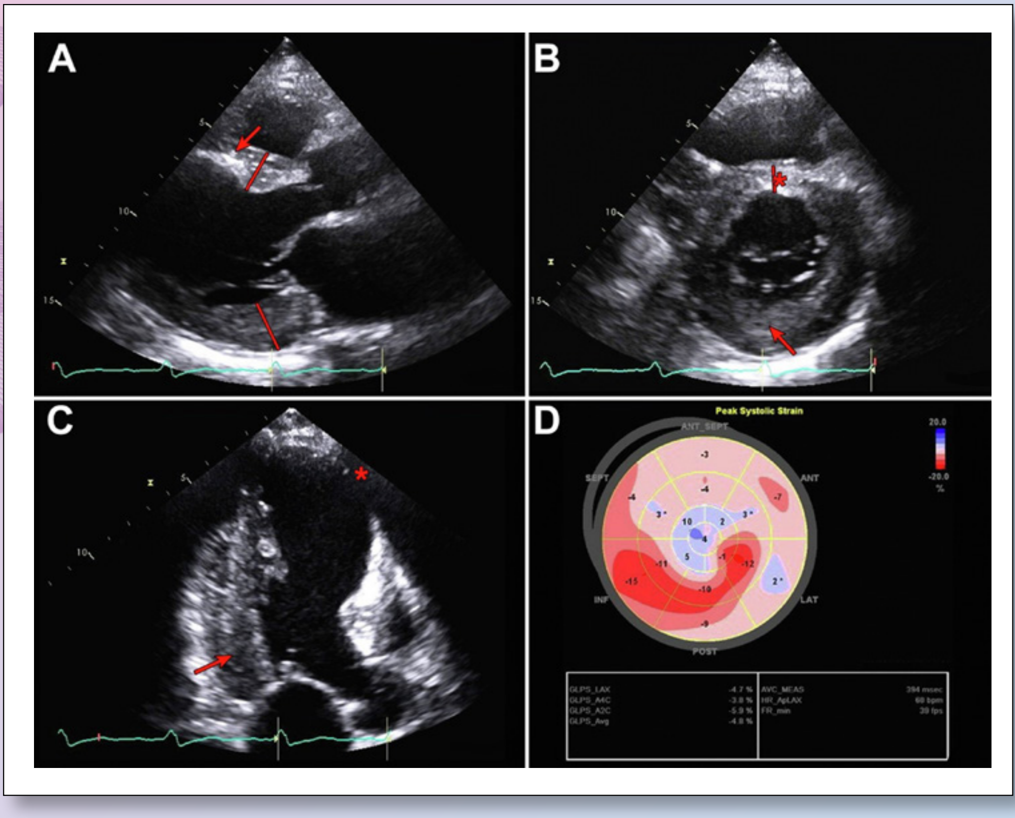

FIGURE 10 Atypical strain pattern in a patient with prior anterior septal apical myocardial infarction and subsequent amyloid infiltration in the noninfarcted segments. (A) Thickening of the basal segments (solid lines) due to amyloid infiltration; the arrow demonstrates scarred segment from previous myocardial infarct. (B) Asterisk at scarred segment; the arrow demonstrates posterior wall thickening. (C) The arrow shows inferolateral thickening; the asterisk shows anterior-apical scar. (D) Classic apical-sparing pattern is absent due to infarction. Cardiac amyloid was proven by endomyocardial biopsy.

SERIAL ASSESSMENT USING ECHOCARDIOGRAPHY

Several studies looking at echocardiographic assessment of disease progression and response to therapy have shown potential benefit for the use of echocardiography in the following areas:

1. To demonstrate changes in cardiac disease in response to treatment in patients with AL and ATTR CA[15,16]
2. To determine whether patients with cardiac amyloidosis need to be anticoagulated for stroke prophylaxis[17]
3. To diagnose progressive cardiac involvement after liver transplantation in patients with vATTR amyloidosis[18]
4. To assess LVEF in patients with AL amyloidosis who are being considered for stem cell transplantation[19]

Emerging data suggest that echocardiographic LV GLS may be a marker of disease progression and response to therapy.[20]

SUPPLEMENTARY DATA

VIDEO 1
Sampling issues with pulsed-wave Doppler of mitral valve inflow.

VIDEO 2
Sampling issues with mitral annular tissue Doppler imaging.

VIDEO 3
Inaccurate strain ROI size affecting strain values.

VIDEO 4
Poor ECG tracking/gating affecting the strain pattern.

TABLE 4 Standardized acquisition and interpretation of echocardiography for CA (adapted from Expert Consensus Recommendations)

Parameter for acquisition and reporting	Abnormal parameter	Notes
LV wall thickness	Increased LV wall thickness (>1.2 cm) and increased relative wall thickness (>0.42)	Discordance between increased LV wall thickness relative to ECG QRS voltage is particularly suggestive, but normal ECG voltage can also be seen.
Myocardial echogenicity	Increased echogenicity of the myocardium (sparkling, hyperrefractile "texture" of the myocardium)	Not highly specific (differential diagnosis includes end-stage renal disease or other infiltrative cardiomyopathies); highly suggestive in conjunction with severely reduced longitudinal function of the LV.
Atrial size and function	Atrial enlargement and dysfunction (see diastolic function)	Nonspecific but important finding to support the diagnosis and potentially provide insight into risk for stroke or arterial embolism.
Interatrial septum and valves	Increased thickening of the interatrial septum and valves (>0.5 cm)	Nonspecific but suggestive of the diagnosis.
Pericardial effusion	Pericardial effusion	Nonspecific but when coupled with other echo signs is suggestive of the diagnosis.
Diastolic function	Grade II or worse diastolic dysfunction with high E/A ratio (>1.5) and reduced E deceleration time (<150 msec).	Doppler diastolic function is helpful in determining prognosis. Severely reduced A wave velocity can be due to LA failure, which can be helpful in determining risk of stroke. An A wave <30 cm/sec portends a higher risk of thromboembolism in sinus rhythm in CA. Assessment of pulmonary vein atrial reversal may be suggestive of increased LV end-diastolic pressure and atrial function.
Estimated PA systolic and right atrial pressure	Increased pressures (>35 mm Hg for PA, ≥10 mm Hg for right atrium)	These are important parameters to estimate volume status and optimize diuretic dosing.
Mitral annular tissue Doppler velocities	Reduced tissue Doppler s', e', and a' velocities	If present, the "5-5-5" sign (all tissue Doppler imaging velocities <5 cm/sec) can be useful and is typically highly suggestive of the diagnosis but may not be sensitive for the diagnosis in early forms of the disease.
Longitudinal LV strain	Decreased global longitudinal LV strain	2D and speckle-tracking echocardiography shows characteristic appearance of myocardial deformation in patients with CA.
Longitudinal LV strain bull's-eye map	Relative preservation of apical longitudinal strain compared to basal and mid-LV longitudinal strain (average apical LS/average combined mid + base LS of >1)	Characteristic bull's-eye pattern is likely the most specific sign to rule in the diagnosis of CA

LS, Longitudinal strain; *PA*, pulmonary artery.

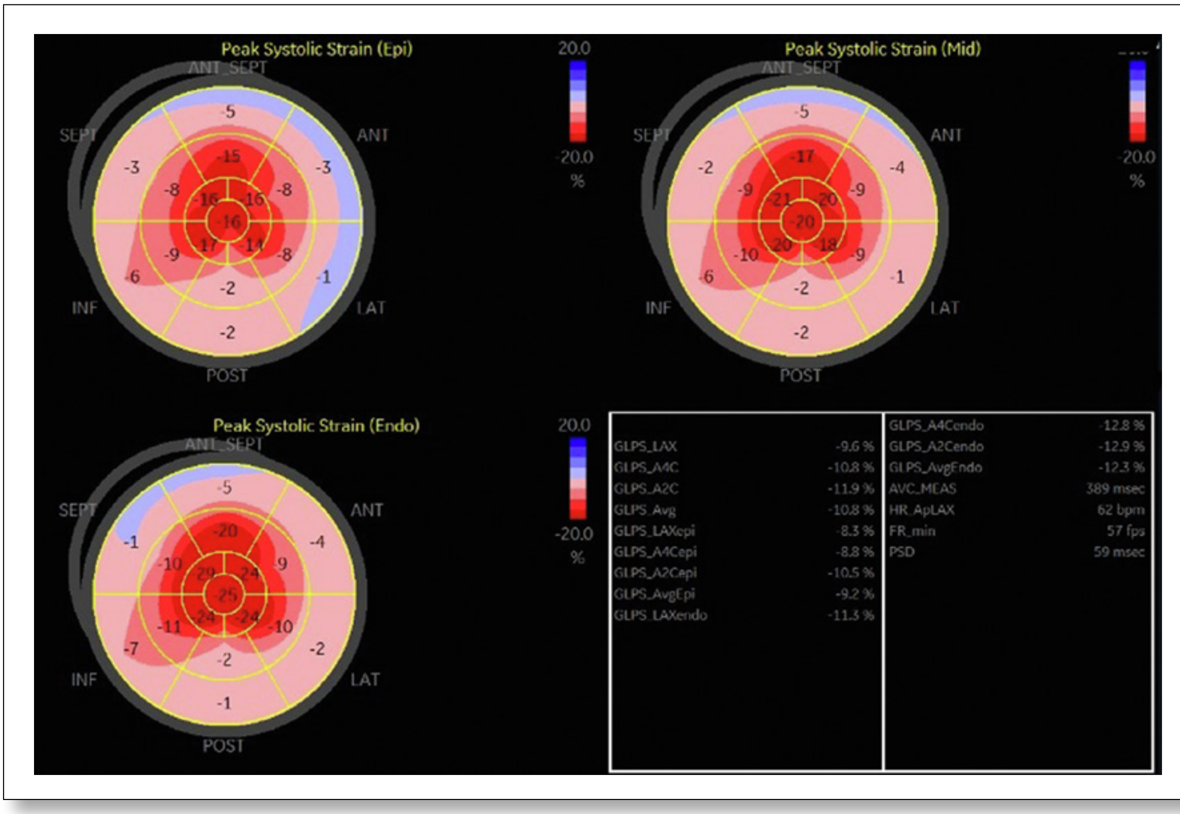

FIGURE 11 Global longitudinal strain values at the endocardial, mid, and epicardial layers. There is a notable gradient from endocardium to epicardium in the apical segments, showing the potential impact of misplacing the ROI.

TABLE 5 Categories of echocardiographic findings in CA (adapted from Expert Consensus Recommendations)

Not suggestive	Normal LV wall thickness Normal LV mass Normal atrial size Septal or lateral mitral annular e' velocity >10 cm/sec
Strongly suggestive*	Increased LV and/or RV wall thickness Increased LV mass Restrictive filling pattern Typical apical-sparing LV longitudinal strain pattern Septal or lateral mitral annular e' velocity <5 cm/sec Biatrial enlargement Small mitral A wave in sinus rhythm Small pericardial and or pleural effusions
Equivocal	Findings not described above

*In the absence of a history of poorly controlled hypertension.

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