Cleveland Clinic

CardiacConsult

Heart, Vascular and Thoracic News from Cleveland Clinic | 2021 | Issue 3

› CARDIAC CONSULT FEATURE

Rethinking Reoperative Risk – p. 4

Dear Colleagues,

Cleveland Clinic's Miller Family Heart, Vascular & Thoracic Institute is honored to be recognized as the nation's No. 1 cardiology and heart surgery program for the 27th straight year in *U.S. News & World Report's* "Best Hospitals" rankings for 2021-22.

This issue of *Cardiac Consult* offers windows into a few of the principles and values that enable our program to sustain this enduring leadership:

Volume-based expertise and commitment to continuous improvement. As one of the world's busiest programs for cardiac, vascular and thoracic care, we manage an unusually high number of complex cases, and we meticulously monitor the case outcomes to learn how to keep improving our care. As our cover story on re-operative cardiac surgery illustrates, this combination has enabled us to drive down the surgical risk of our reoperations to levels that approach those of primary cardiac surgery.

An ethos of innovation. This ethos is exemplified in a number of stories, from the profile of advancements in the application of cardiac MRI on page 7 to the discussion of our contributions to the evolution of ultra-hybrid thoracoabdominal aortic aneurysm repair on page 14. And page 3's recap of the world's first documented stopped-heart operation — performed at Cleveland Clinic back in 1956 — makes clear that this ethos of innovation has deep roots here.

Thank you for your collaboration over the past 27 years.
We remain dedicated to earning your continued confidence.

Respectfully,

Lars G. Svensson, MD, PhD

CHAIR | Sydell and Arnold Miller Family Heart, Vascular & Thoracic Institute

Cardiac Consult is produced by Cleveland Clinic's Sydell and Arnold Miller Family Heart, Vascular & Thoracic Institute.

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BEST HOSPITALS U.S.News & WORLD REPORT CARDIOLOGY & HEART SURGERY 2021-22

Cleveland Clinic was named a top U.S. hospital in *U.S. News & World Report*'s "Best Hospitals" rankings for 2021-22, as well as the No. 1 hospital in cardiology and heart surgery for the 27th consecutive year.

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Cleveland Clinic at 100:
Stopping the Heart Starts a New Surgical Era

Most of the 500,000 heart surgeries performed each year in the U.S. use potassium-induced cardioplegia and thus have roots reaching back to a seminal Cleveland Clinic operation in 1956. As Cleveland Clinic marks its centennial in 2021, *Cardiac Consult* looks back on that operation's legacy.

The case in brief

A 9.5-month-old male infant was referred to Cleveland Clinic in May 1955 for failure to thrive, inability to sleep lying flat and recurrent episodes of pulmonary edema. His evaluation eventually led to cardiac catheterization, which revealed a high ventricular septal defect and pulmonary hypertension.

The catheterization was performed by F. Mason Sones, MD, the cardiologist who three years later pioneered coronary angiography. Dr. Sones advised the patient's parents of research by cardiothoracic surgeon Donald Effler, MD, on use of a cardiopulmonary bypass pump designed by Cleveland Clinic's Willem Kolff, MD, PhD, to close heart defects. Despite being told the operation carried a 25% to 30% risk of death, the parents agreed to proceed with surgery to repair the defect using the pump.

The boy was 17 months old when he underwent the operation in February 1956, weighing just 17 pounds. Once Dr. Kolff's early heart-lung machine was pumping blood and oxygen, a dose of potassium citrate temporarily paralyzed the boy's heart.

The surgery was led by Dr. Effler and Larry Groves, MD, who noted that the pulmonary artery was significantly enlarged, under high pressure and located in an unusually anterior position in the chest. The surgeons used a transverse chest incision, tied off the distal left subclavian artery and used the proximal subclavian for arterial inflow with caval cannulation and caval occlusion. Employing a trans right ventricle approach, they closed the ventricular septal defect — described as "the size of a 5-cent piece" — with four interrupted silk sutures. Total pump time was 17 minutes.

A Cleveland Clinic team led by surgeons Donald Effler, MD, and Larry Groves, MD, performs a stopped-heart operation in 1956 using the heart-lung bypass machine developed by Willem Kolff, MD, PhD. Photo courtesy of Cleveland Press Collection, Cleveland State University.

After the heart was reperfused, spontaneous sinus rhythm returned. The boy's recovery was unremarkable and he was discharged six days after surgery.

By the time he was 3 years old, the boy achieved normal height and weight levels. He returned to Cleveland Clinic for regular monitoring until he was 14, and he was among the earliest patients assessed with the coronary angiographic techniques developed by Dr. Sones in 1958. Now 66 years old, he is a retired professional trumpeter who has not experienced any cardiovascular events since his surgery as a 17-month-old.

Era of stopped-heart surgery begins

This case — the first documented operation in which a patient's heart was stopped with aortic occlusion and potassium citrate infusion on a cardiopulmonary bypass pump — was instrumental in establishing stopped-heart surgery as a regular practice. "With a dry, quiet, clearly visible field in which to work, we believe that a new era of heart surgery has opened," observed Dr. Effler at the time.

His remark proved prescient, notes Lars Svensson, MD, PhD, Chair of Cleveland Clinic's Heart, Vascular & Thoracic Institute. "Every day, surgeons around the world stop the heart for most types of heart surgery using a process similar to the one pioneered by Drs. Effler and Groves," he says. "Even today, closing a hole in the heart in 17 minutes is remarkable. This case reminds us that the pioneers of cardiac surgery were heroes for attempting operations with uncertain outcomes. The innovation and commitment embodied by this milestone stopped-heart operation are qualities we continue to emulate at Cleveland Clinic to the present day." ■

For more insights from Dr. Svensson on this pivotal operation, see his video at ccf.org/stoppedheartvideo.

RETHINKING RISK IN

REOPERATIVE

CARDIAC SURGERY

LARGE SERIES SUGGESTS A NEW FRONTIER IN SAFETY

At high-volume centers with meticulous preoperative planning, the surgical risk of reoperative cardiac surgery can be driven down to levels approaching those of primary cardiac surgery. So suggests an observational outcomes study among more than 6,600 reoperative cardiac surgery cases over a recent 9.5-year period at Cleveland Clinic.

The study, published online in the *Journal of Thoracic and Cardiovascular Surgery* earlier this year, revealed overall reoperative mortality of 3.5% and low rates of stroke, renal failure, deep sternal wound infection and other complications despite high case complexity. Outcomes were comparably favorable regardless of whether cardiopulmonary bypass (CPB) was instituted early or late.

"These results are exceptional because they included emergency procedures, endocarditis cases and patients with multiple previous sternotomies," says the study's corresponding author, cardiothoracic surgeon Faisal Bakaeen, MD. "Many patients were referred from other hospitals or were self-referred, with some deemed 'inoperable' prior to evaluation at Cleveland Clinic. These findings are a testament to the value of volume-based surgical experience and the use of a multidisciplinary heart team approach when evaluating risk of sternal reentry and choosing a surgical strategy for reoperative cases."

"Our findings constitute strong evidence that reoperative sternotomy is safe and adds only minimally to operative risk when done by experienced teams," adds co-author Lars Svensson, MD, PhD, Chair of Cleveland Clinic's Heart, Vascular & Thoracic Institute.

Rationale and design

These surgeons and their colleagues undertook the analysis to assess current practice and outcomes of reoperative surgery, with a focus on the use of image-guided stratification of sternal reentry risk and the usefulness of peripheral cannulation to initiate CPB prior to resternotomy.

"Peripheral cannulation and early cardiopulmonary bypass are employed to avoid or attenuate catastrophic injury and manipulation, but their routine use is controversial due to the need for early heparinization and risks of excessive bleeding and cardiopulmonary bypass time," says Dr. Bakaeen. "We sought greater insight on their effects in real-world practice."

The researchers examined records of all 7,640 patients who underwent reoperative cardiac surgery at Cleveland Clinic from January 2008 to July 2017. Patients without preoperative CT scans, those who did not undergo resternotomy or CPB, and those who underwent heart transplant or endovascular stenting of the thoracic aorta were excluded. The remaining 6,627 patients made up the study cohort and were stratified in two ways:

- By timing of CPB initiation — i.e., before resternotomy in 755 (early CPB) vs. after resternotomy in 5,872 (late CPB)
- By anatomic risk of reentry based on CT criteria — 563 were deemed high risk and 6,064 were deemed low risk

Endpoints were operative mortality and major morbidity (i.e., stroke, myocardial infarction, prolonged ventilation, renal failure with dialysis, deep sternal wound infection). Within each anatomic risk group, weighted propensity scores for mortality and morbidity were generated to allow comparisons by timing of CPB.

Reoperations most commonly included aortic valve replacement (n = 3,611), coronary artery bypass grafting (CABG) (n = 2,029), aortic root surgery (n = 1,061) and aortic arch surgery (n = 527).

Key outcomes

Operative mortality for the full cohort was 3.5% (235/6,627), with statistically comparable rates of 4.1% and 3.5% in the early and late CPB groups, respectively. Major sternal reentry and mediastinal dissection injuries were uncommon (2.8% incidence).

In the high-anatomic-risk cohort, propensity-weighted analysis revealed no significant differences in mortality or in any major morbidities between the early and late CPB groups. There was likewise no significant difference in long-term survival. The only significant between-group differences were in intraoperative blood product transfusions, which were higher in the early CPB group, and postoperative platelet infusions, which were higher in the late CPB group.

In the low-anatomic-risk cohort, propensity-weighted analysis again showed similar operative and long-term mortality rates and rates of all major morbidities between the early and late CPB groups. However, the late CPB group experienced significantly higher rates of major reentry and dissection injuries (2.8% vs. 0.8%) and had longer myocardial ischemic times and higher rates of postoperative atrial fibrillation. As in the high-risk cohort, significantly more patients in the early CPB group required intraoperative blood product transfusions.

Pillars of reoperative success

"This study shows that reoperative cardiac surgery can be performed with high levels of safety and few major sternal reentry and mediastinal dissection injuries regardless of the timing of cardiopulmonary bypass," says Dr. Bakaeen. "The key ingredient is volume-based experience using established quality and rescue protocols."

In their study report, the authors outline specific critical elements — in addition to institutional experience — that contribute to reoperative success, as summarized below:

- **A multidisciplinary heart team approach** involving close collaboration among cardiovascular imaging specialists, cardiologists, cardiac surgeons, cardiac anesthesiologists, critical care specialists, perfusionists, transfusion specialists, nurses and others.
- **Imaging guidance to determine sternal reentry risk,** which has particular value for patients with high anatomic risk. At Cleveland Clinic, CT scans are routinely taken before reoperative surgery, and contrast is used in cases of suspected aortic disease with no kidney disease.
- **Deliberate planning for vigilant myocardial protection,** particularly when a patent left internal thoracic artery graft is present. The authors note that low rates of intra-aortic balloon pump and extracorporeal membrane oxygenation use in this large series confirm robust myocardial protection in this complex patient population.
- **Deployment of endovascular adjuncts if needed,** particularly in high-risk cases presenting a challenging environment for repeat sternotomy. These adjuncts, which include endovascular aortic balloon occlusion and percutaneous cardioplegic arrest, are used before or after sternal reentry to avoid or limit the duration of circulatory arrest. Such strategies may require a hybrid operating room.

continued next page

- **A robust continuous quality improvement (CQI) process.** At Cleveland Clinic, a formal CQI process is in place to report outcomes of reoperations and other operative categories on a monthly basis, both in total and for individual surgeons. Moreover, reoperations and other complex cases are discussed at weekly conferences designed to optimize patient selection and operative strategy.
- **Active communication among the operating room team,** including structured briefings and debriefings for all team members to cover roles, responsibilities and rescue plans.
- **Proactive training in readiness.** At Cleveland Clinic, senior surgeons typically assist new and junior staff surgeons on high-risk reoperative cases to cultivate preparedness for rescues and accelerate training in the most complex cases.

Adoption or enhancement of these elements may help explain improvements from a previous Cleveland Clinic series of reoperative cases (*J Thorac Cardiovasc Surg.* 2008;135:316-323). Overall reoperative mortality declined from 4.5% in that earlier report to 3.5% in the present study, and rates of major reentry- and dissection-associated injuries were reduced by more than half. "Since that earlier series," the authors write, "we have mandated preoperative CT scans and more consistently adopted common reoperative strategies and surgical practices to prevent adverse events."

When CPB timing might matter most

While the current analysis found no outcome benefits with one CPB timing strategy over the other, the authors identified several scenarios where a particular approach might be favored.

An early CPB strategy or endovascular adjunct is advised when imaging findings suggest a high risk of injury — such as adherence of an aortic pseudoaneurysm or a patent bypass graft to the chest wall — and when performing isolated aortic valve or aorta surgery. In contrast, a late CPB strategy is favored for CABG and mitral valve surgery in cases with low anatomic risk and in multicomponent operations that demand extensive dissection.

Cleveland Clinic Reoperative Cardiac Stats at a Glance

› **1,117 adult cardiac surgery reoperations in 2020, including:**

- 190 second reoperations
- 46 third reoperations
- 23 fourth or additional reoperations

› **0% operative mortality in 2020 for reoperations involving all of the following:**

- Isolated coronary artery bypass grafting (CABG)
- Isolated aortic valve replacement (AVR)
- Isolated mitral valve (MV) repair
- AVR + CABG
- MV replacement + CABG
- MV repair + CABG

A pathway forward for revisiting reoperative risk

In a commentary that accompanied the study report, two cardiac surgeons from Sunnybrook Health Sciences Center in Toronto commend the Cleveland Clinic authors for "encouraging the cardiac surgical community that redo surgery can consistently result in positive outcomes and may trend toward outcomes similar to primary surgery."

They further write that the study presents "a potential pathway forward toward reducing surgical risk with reoperation that may be generalizable to a greater number of surgical centers."

Cleveland Clinic's Dr. Svensson concurs that there are lessons here for other high-volume centers. "Our results demonstrate that redo operations do not of necessity add to procedural risk," he says. "Prior sternotomy should not prohibit treatment or prompt automatic or inappropriate triage to transcatheter valve-in-valve procedures or percutaneous or endovascular repairs. In the right hands, reoperations are safe and can yield excellent outcomes." ■

Contact Dr. Bakaeen at 216.444.0355 and Dr. Svensson at 216.444.6962.

Cardiac Magnetic Resonance Imaging: 7 New & Emerging Developments to Be Aware Of

Advancements are expanding applications and improving accuracy and patient experience

Ever since 1983, when Cleveland Clinic erected a building designed to house its first magnetic resonance imaging (MRI) scanner, it has been exploring new clinical applications for MRI. Some of the most important gains have been made in cardiac MRI, or CMR.

Cleveland Clinic is now one of the highest-volume CMR centers in the country, conducting over 4,000 scans a year on two dedicated cardiac MRI scanners. *Cardiac Consult* caught up with Deborah Kwon, MD, Director of Cardiac MRI, to talk about recent and emerging developments in the field. Seven of them are briefly recapped below.

1) Shortening scan times with compressed sense

Cleveland Clinic is using an acceleration technique called compressed sense to perform CMR scans in a more efficient manner. Whereas a typical CMR scan to evaluate cardiac function and myocardial fibrosis/viability usually takes 45 to 60 minutes to complete, myocardial function and tissue characterization MRI studies are typically completed in 30 minutes at Cleveland Clinic using compressed sense.

"Compressed sense is based on the understanding that there is redundant information in signal acquisition," explains Dr. Kwon. "This technique enables the acquisition of undersampled data, specialized signal processing and image reconstruction to provide high-quality images. To the eye, images acquired using compressed sense look almost identical to images acquired conventionally."

Compressed sense can be applied to all CMR protocols. "A shorter scan time is important for patient comfort, as well as for CMR image quality, as patients typically get tired during long scans," Dr. Kwon notes. "This can frequently result in inadequate and inconsistent breath-holding, which results in motion artifacts that degrade CMR image quality. Shorter scan times and better image quality is always a win-win combination."

For a brief video of short-axis cine image acquisition using compressed sense, see the online version of this article at **ccf.org/cardiacmri**.

2) Avoiding the need for breath-holding

Patients who have trouble holding their breath can benefit from another new development — a CMR technique that gates cine acquisition with respiratory bellows to allow free breathing during cine image acquisition. In this technique, the signal is triggered by the motion of the diaphragm as well as the heart. "The scans take slightly longer to perform, but this technique has yielded very nice image quality," Dr. Kwon observes. "And the ability to perform free-breathing cine imaging can be particularly useful for patients who have trouble performing adequate breath holds, which is frequently the case in those with congestive heart failure."

For a brief video of free-breathing cine image acquisition using the respiratory bellows gating technique, see the online version of this article at **ccf.org/cardiacmri**.

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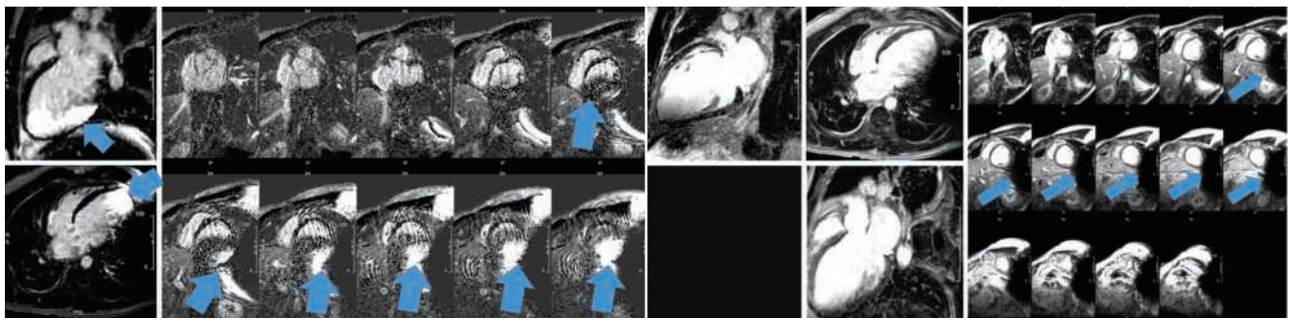


Figure 1. (Left) Late gadolinium enhancement (LGE) images in a patient with a subcutaneous ICD without wideband phase-sensitive inversion recovery (PSIR) technique. (Right) LGE images in the same patient using wideband PSIR technique with a frequency offset of 750 Hz, with resulting artifact minimization.

3) Minimizing artifact from pacemakers and ICDs

To overcome artifact-related limitations of CMR in patients with pacemakers and implantable cardioverter-defibrillators (ICDs), Cleveland Clinic utilizes an image optimization protocol that uses a wideband imaging technique to minimize artifacts seen on late gadolinium enhancement (LGE) imaging (Figure 1).

"With this technique, we get adequate images on about 70% to 80% of patients with ICDs, even when the devices are not MRI-compatible," says Dr. Kwon. In the remaining 20% to 30%, close proximity of the ICD to the heart results in significant artifact that obscures a substantial percentage of the heart, which cannot be minimized.

4) Revealing myocardial contractility with fast-SENC

Fast strain-encoded (SENC) CMR imaging (fast-SENC) is a novel technique that enables assessment of cardiac contractility in a single heartbeat (Figure 2). This technique can identify diseases of the myocardium, including heart failure with preserved ejection fraction and myocardial ischemia, and has promising utility for screening patients in cardio-oncology clinics. The utility of fast-SENC is currently being assessed at Cleveland Clinic for patients with significant valve disease.

"Fast-SENC has demonstrated superior reproducibility for assessing segmental strain," says Dr. Kwon. She adds that its superior reproducibility of assessing segmental strain results in more accurate assessment of strain than is achieved with other forms of CMR-based strain assessment or with echocardiography.

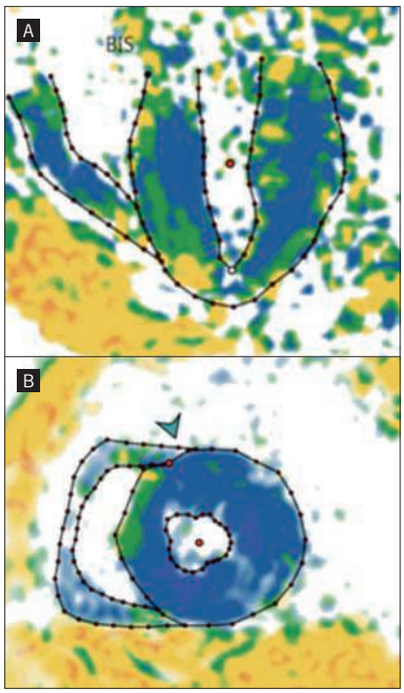


Figure 2. (A) A four-chamber fast-SENC image. (B) A short-axis fast-SENC image.

"Some segments of the myocardium may have abnormal contractility, while other segments may become hypercontractile to compensate," Dr. Kwon explains. "Therefore, averaging the strain of all segments to provide a global strain value may not be sensitive enough to discern underlying disease. Calculating the number of segments with abnormal strain may provide a more sensitive technique for identifying subclinical myocardial disease. But this requires a technique that provides accurate and reliable segmental measurements. Fast-SENC holds promise for identifying patients early in their myocardial disease trajectory who are at risk for declining contractility over time and may benefit from early therapeutic intervention."

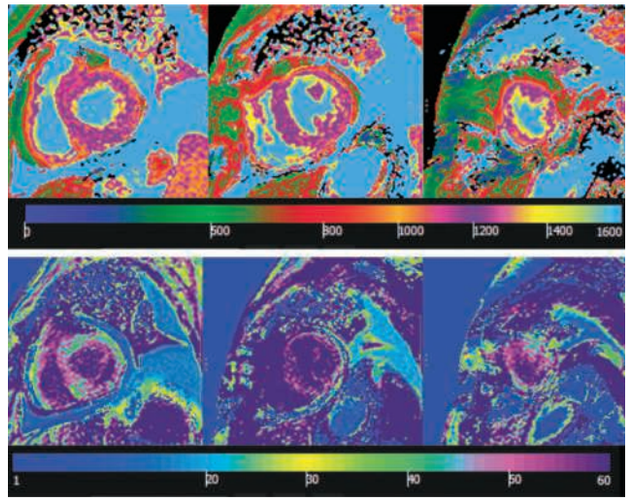


Figure 3. Quantitative parametric mapping. (Top row) Precontrast T1 mapping in a patient with cardiac amyloidosis. (Bottom row) Mapping with extracellular volume quantification.

5) Quantitative myocardial parametric mapping

Cleveland Clinic routinely uses parametric mapping with T1 mapping and extracellular volume (ECV) quantification to provide quantitative measurements of the myocardium (Figure 3). The technique can be useful for identifying diffuse fibrosis, myocarditis and cardiac amyloidosis. T2 mapping can be performed to provide quantitative measures of myocardial edema, which can be important for diagnosing active sarcoidosis or other inflammatory myocardial diseases. Quantitative parametric mapping with T1/T2 mapping has lately gained prominence because these techniques were the primary indicators used to characterize COVID-19-related myocarditis in recent literature reports.

"We have been performing T1 mapping routinely since 2014, and it has emerged as an important tool, particularly for identifying early stages of cardiac amyloidosis," Dr. Kwon notes. "Centers typically rely on LGE imaging to identify

patients with cardiac amyloidosis, but LGE assessment can miss amyloidosis in up to 15% of patients who are in the early stages. T1 mapping and ECV quantification provide significantly more sensitive measures to identify more subtle and diffuse abnormalities in myocardial tissue. T1 and T2 mapping may also be important for identifying early stages of myocarditis secondary to viral illness or in cancer patients undergoing chemotherapy."

6) CMR fingerprinting

CMR fingerprinting (cMRF) has recently emerged as a novel and robust quantitative parametric technique that enables quantification of T1 and T2 values in a single breath-hold (Figure 4). In addition to streamlining protocols and making scanning more efficient, cMRF may provide further tissue characterization beyond T1/T2 measures, such as fat fraction, perfusion, diffusion, T2* and the ability to quantify ECV without gadolinium-based contrast agents. cMRF is still in the research stage, but Dr. Kwon expects to implement this technique for clinical scans at Cleveland Clinic later this year.

7) Stress testing with a supine MRI-compatible ergometer

To conduct MRI stress testing, an exercise ergometer made specifically for use in MRI scanners can be loaded onto the scanner table. Resting images are acquired, after which the patient cycles for up to 10 minutes with his or her chest inside the magnet. Cine imaging and strain imaging can then be acquired while the patient is still cycling to assess heart function at rest and under stress (Figure 5).

Figure 5. Photos showing a volunteer using the ergometer in an MRI scanner while Dr. Kwon and a colleague view the resulting images on a monitor.

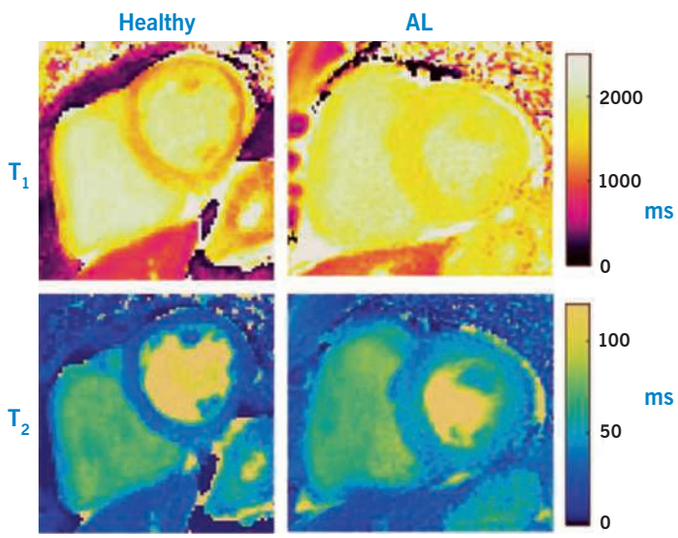


Figure 4. CMR fingerprinting for characterization of a healthy volunteer relative to a patient with AL amyloidosis (AL).

"The biggest hurdle has been imaging patients while exercising due to increased respiratory rate, increased heart rate and increased body motion from cycling — these are all obstacles to acquiring good CMR images," Dr. Kwon explains. "By using compressed sense and shortening breath-holds to 3 seconds, we have been able to address some of these challenges, but image optimization is still ongoing."

The test is being developed for use in asymptomatic patients with valvular heart disease and heart failure with preserved ejection fraction, in whom changes are likely visible at sub-maximal exercise levels. "It is more sensitive for patients with early signs of myocardial disease and will be useful when we are unsure whether a patient should have surgery," she says.

The imaging protocol during exercise is being refined on healthy volunteers with the goal of conducting research studies to determine clinical feasibility and utility. ■

Contact Dr. Kwon at 216.444.8526.

Severe Atrial Functional Mitral Regurgitation: Study Presents Most Detailed Profile to Date

Atrial functional mitral regurgitation (AFMR) has been a neglected clinical entity. Although it has been described for at least a decade, AFMR is underrecognized, undertreated and rather poorly understood.

That might be starting to change, however, with the recent publication of a Cleveland Clinic study in *JACC: Cardiovascular Imaging* (2021;14:797-808) believed to represent the largest cohort of patients with severe AFMR identified by transesophageal echocardiography (TEE) reported to date.

"AFMR is neither primary mitral regurgitation (MR), which is a valve problem, nor the typical functional or secondary MR, which is ventricular in origin. Rather, it is functional MR of atrial origin," says the study's corresponding author, Serge Harb, MD, staff cardiologist in Cleveland Clinic's Section of Cardiovascular Imaging.

"Patients with AFMR have not been studied separately in clinical trials, and literature about AFMR is sparse," Dr. Harb continues. "As a result, there are no guidelines to advise physicians on how to approach this problem, which carries a poor prognosis."

"The mitral valve is equipped to withstand the highest pressure in the heart," says study co-author Samir Kapadia, MD, Chair of Cardiovascular Medicine. "This study characterizes the mechanism and contribution of left atrial dilation on mitral apparatus dysfunction in a large Cleveland Clinic population. This mechanistic insight is critical for proper and timely interventions to prevent and treat mitral regurgitation."

Shedding light on AFMR

The growing number of patients presenting with MR and normal ventricular function in the absence of leaflet pathology prompted the Cleveland Clinic team to better define the clinical entity they were seeing.

They screened all patients who had undergone TEE at Cleveland Clinic between 2011 and 2018 for severe MR with preserved left ventricular function. After patients with endocarditis, cardiomyopathy or prior mitral valve intervention were excluded, a cohort of 283 patients remained. Of this cohort, 39 (14%) had AFMR and 244 (86%) had primary MR.

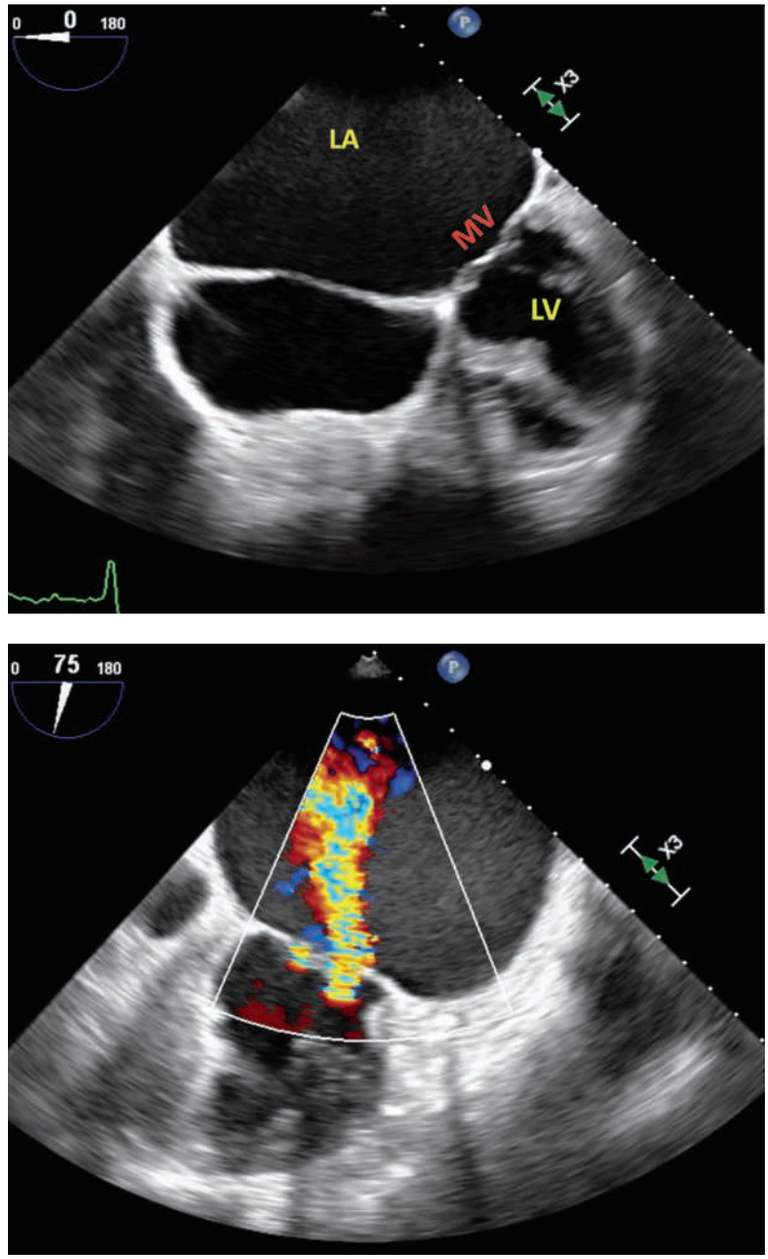


Figure. Top TEE shows a markedly enlarged left atrial (LA) cavity with no mitral valve (MV) leaflet pathology and a normal left ventricle (LV). Bottom TEE shows severe AFMR.

> Mitral annular dilation with insufficient leaflet remodeling is the most commonly described feature [of atrial functional mitral regurgitation].
>
> — SERGE HARB, MD

When the AFMR and primary MR groups were compared, patients with AFMR had significantly higher rates of hypertension, diabetes mellitus, long-standing atrial fibrillation, pacemaker placement and prior nonmitral cardiac surgery.

"Atrial fibrillation and diastolic dysfunction were the main risk factors," says Dr. Harb.

Over a median follow-up of 22 months, mortality was significantly higher among patients with AFMR relative to those with primary MR (41.0% vs. 18.9%; $P = 0.004$). On multivariable regression analysis, AFMR was independently associated with mortality (odds ratio = 2.61; 95% CI, 1.17-5.83; $P = 0.02$).

Patients with AFMR also were twice as likely as their primary MR counterparts to be hospitalized for heart failure (51.3% vs. 25.4%; $P = 0.002$).

Salient characteristics

AFMR is distinguished by atrial dilation and annular remodeling. "Mitral annular dilation with insufficient leaflet remodeling is the most commonly described feature," notes Dr. Harb. "Malcoaptation of the leaflets results in a central jet of regurgitation that can be clearly seen on transesophageal echo."

In other cases, the posterior annulus is stretched outward and herniates over the left ventricular free wall. This causes tethering of the posterior leaflet and a predominantly posterior jet of regurgitation.

"Typically, AFMR requires transesophageal echo to ascertain," Dr. Harb explains (see figure). "However, the diagnosis of MR should start with a transthoracic echo and proceed to transesophageal echo if an unusual form of MR is suspected, in which case transesophageal echo can help elucidate the features of AFMR."

Surgery can help — but is less often undertaken

Surgery can improve outcomes in AFMR. Compared with conservative management, mitral valve surgery was associated with improved survival in AFMR (log-rank $P = 0.021$). Also, none of the 10 AFMR patients who underwent surgical mitral valve repair developed significant MR on follow-up or needed further mitral interventions.

Nevertheless, patients with AFMR were less likely than their primary MR counterparts to undergo a mitral intervention of any kind (59.0% vs. 83.6%; $P = 0.001$). Dr. Harb attributes this to increased risk conferred by older age, significant comorbidities and frequent prior cardiac surgery — as well as a lack of guidelines for managing these patients.

"Distinguishing atrial functional MR from other causes of mitral regurgitation is very important," observes study co-author Marc Gillinov, MD, Chair of Thoracic and Cardiovascular Surgery. "In many cases, an operation that includes both mitral valve repair and a maze procedure for atrial fibrillation reduces symptoms and improves patient quality of life."

A case for prevention

Dr. Harb notes that comprehensive guidance on the best way to manage patients with AFMR "is something for future research to provide."

In the meantime, he says, preventing the onset of severe MR is the best option. "Practice aggressive rhythm control to restore sinus rhythm and treat diastolic dysfunction before severe MR develops," he advises. "If you cannot prevent it, and the patient develops severe AFMR, mitral valve repair or replacement may improve survival." ■

Contact Dr. Harb at 216.444.3316, Dr. Kapadia at 216.444.6735 and Dr. Gillinov at 216.445.8841.

TMAO's Prognostic Value Extends to Incident Coronary Artery Disease in Healthy Adults

First robust evidence of the metabolite's predictive power in a primary prevention context

For the first time, the gut microbe-dependent metabolite TMAO has been shown to predict incident coronary artery disease (CAD) in a large prospective population study of apparently healthy adults. The finding, published in *American Heart Journal* (2021;236:80-86) by a Cleveland Clinic-led research team, adds to mounting evidence linking the TMAO pathway to elevated risk of cardiometabolic disease.

"CAD risk increased with plasma TMAO levels in a dose-dependent fashion among our study population of middle-aged individuals with no history of cardiovascular disease," observes the study's lead author, Cleveland Clinic cardiologist W.H. Wilson Tang, MD. "This increase was independent of traditional risk factors."

Assessing TMAO in a primary prevention context

TMAO (trimethylamine *N*-oxide) is produced when gut bacteria digest choline, carnitine and lecithin — nutrients that are abundant in animal products, particularly red meat. This metabolite has been mechanistically linked to atherosclerosis, thrombosis and various forms of cardiometabolic disease through a series of animal model and clinical association studies over the past decade, many of them conducted by a Cleveland Clinic team including Dr. Tang and led by Stanley Hazen, MD, PhD.

Despite this growing body of evidence linking TMAO and cardiometabolic disease, virtually all the clinical studies have been in people with a high risk factor burden or prevalent cardiovascular disease, particularly CAD.

To explore TMAO's impact in the general population, the Cleveland Clinic researchers teamed with European investigators to conduct a nested case-control study among participants in the EPIC-Norfolk prospective population study. This community-based cohort study had recruited over 25,000 apparently healthy men and women between ages 40 and 79 years in the mid-1990s, all of them from Norfolk in the United Kingdom. The purpose of EPIC-Norfolk was to evaluate determinants of cancer and other diseases through long-term follow-up.

The present investigation identified the 908 EPIC-Norfolk participants who developed CAD during an average follow-up period of eight years and individually matched them to 1,273 control EPIC-Norfolk participants by gender, age, enrollment site and date of visit. All participants had nonfasting blood samples taken at enrollment in EPIC-Norfolk, which were used to determine baseline plasma levels of TMAO and other metabolites.

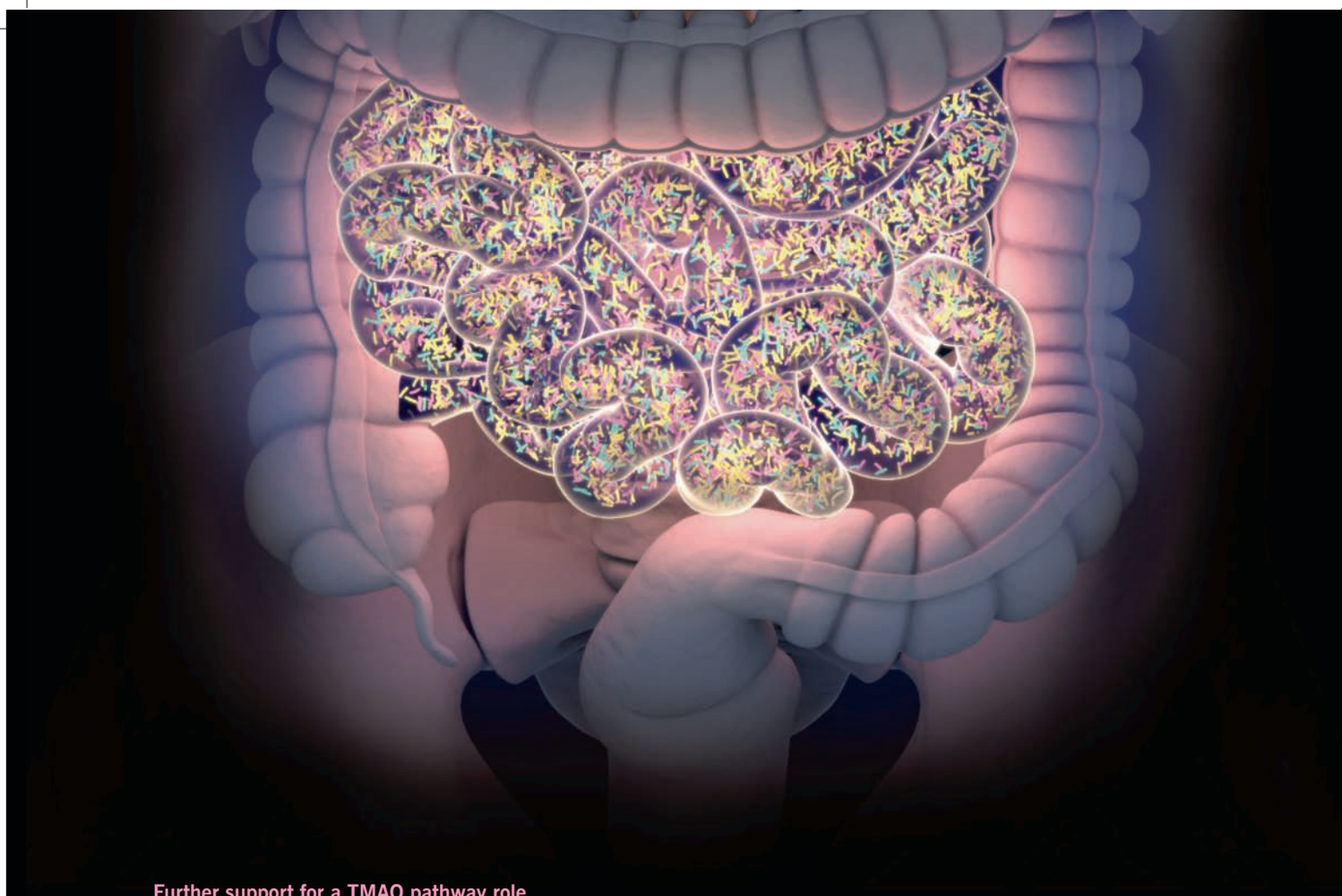
Key findings

Analysis of the 2,181 participants' outcomes by baseline plasma TMAO revealed the following:

- TMAO levels were higher in participants who developed CAD than in those who did not, 3.70 μM (interquartile range [IQR], 2.50-6.41) vs. 3.25 μM (IQR, 2.19-5.21) ($P < 0.001$).
- When the overall cohort was stratified into quartiles according to TMAO level, elevated TMAO was predictive of CAD development, with an odds ratio of 1.86 for the highest versus lowest TMAO quartiles (95% CI, 1.46-2.37) ($P < 0.001$). After adjustment for traditional risk factors, elevated TMAO remained predictive of incident CAD (odds ratio = 1.58; 95% CI, 1.21-2.06) ($P < 0.001$).

Analysis of associations for other metabolites showed plasma choline levels to be predictive of CAD development (although less strongly than TMAO), whereas betaine conferred no significant prognostic value.

The researchers also found that TMAO's predictive utility maintained its statistical significance for all TMAO threshold levels from 1.5 μM (10th percentile) to 10.5 μM (90th percentile), underscoring the dose-dependent relationship between TMAO and incident risks, as well as the concept that "lower is better" across a broad range of TMAO levels. In contrast, choline's prognostic value was less consistent across the cohort, particularly at lower concentration thresholds.



Further support for a TMAO pathway role

"This long-term study of apparently healthy adults found that TMAO levels were higher among those who went on to develop CAD than in those who did not, even after adjustment for other risk factors," says Dr. Tang.

He notes that these findings are consistent with the one previously published prospective study of TMAO levels in a primary prevention context, which was conducted in a much smaller cohort and with shorter follow-up (*Atherosclerosis*. 2019;280:126-131).

"Our study and this small earlier study support the prognostic value of TMAO in the general population and bolster the growing data that link the TMAO pathway to elevated cardiovascular risk," adds Dr. Hazen, Co-Section Head of Preventive Cardiology and Rehabilitation at Cleveland Clinic. "These findings suggest that keeping TMAO levels lower may help reduce incident risk of cardiovascular disease, even in apparently healthy middle-aged adults."

That suggests a potential role for TMAO-lowering strategies within the cardiovascular therapeutic landscape. Clinical studies by this Cleveland Clinic group and others have shown that certain dietary interventions can reduce TMAO levels, and novel pharmacologic interventions that target TMAO production have slowed atherosclerosis progression in mouse studies.

But further study is clearly needed, Dr. Tang notes. "These promising findings warrant further investigation," he says. "The next step is seeing whether TMAO-lowering interventions in patients show the same promising effects seen in animal studies, and if they will actually reduce cardiovascular risks in the clinical setting, whether for primary or secondary prevention."

"We know that eating a healthy diet can have a dramatic impact on the risk of developing cardiovascular disease," observes Leslie Cho, MD, Co-Section Head of Preventive Cardiology and Rehabilitation at Cleveland Clinic. "This noteworthy study helps us understand the important role of the gut microbiome in development of cardiovascular disease."

Disclosure: *Dr. Tang reports no commercial interests relevant to the work discussed above. Dr. Hazen reports being named as co-inventor on pending and issued patents held by Cleveland Clinic relating to cardiovascular diagnostics and therapeutics, as well as having received royalty payments for inventions or discoveries related to cardiovascular diagnostics or therapeutics from Cleveland Heart Lab, a fully owned subsidiary of Quest Diagnostics, and Procter & Gamble.* ■

Contact Dr. Tang at 216.444.2121, Dr. Hazen at 216.444.9426 and Dr. Cho at 216.445.6320.

Ultra-Hybrid TAAA Repair: Insights From the Largest Experience to Date

An ultra-hybrid approach to thoracoabdominal aortic aneurysm (TAAA) repair is a feasible and safe intervention that is coming into its own, thanks in part to the success of thoracic endovascular aneurysm repair (TEVAR) in recent years.

That's a key takeaway from a poster presentation by Cleveland Clinic cardiothoracic surgeon Eric Roselli, MD, at the 2021 annual meeting of the American Association for Thoracic Surgery (AATS). The data presented represents the largest experience with the procedure reported to date.

The concept of ultra-hybrid repair

"As TEVAR has been applied to more and more people with thoracic aortic disease, and as medical therapy has improved, we see more patients survive to the point where their disease progresses and they need treatment that goes beyond what was addressed with an earlier stent graft in the thoracic aorta," says Dr. Roselli, Cardiac Surgery Director of Cleveland Clinic's Aorta Center. "In many cases we can extend and complete the repair through an open operation in which we sew an additional graft into the prior stent graft, resulting in what we call an ultra-hybrid repair with open thoracoabdominal completion after descending stent grafting."

He notes that the above scenario is one of several situations in which the procedure is offered. Another scenario involves patients with extensive aortic disease affecting everything from the aortic root through the descending aorta. In such cases, an open procedure with sternotomy is performed first to enable root repair and frozen elephant trunk repair. "We do the next part endovascularly with TEVAR through the groin, and then we give the patient a break and bring them back later for open thoracoabdominal completion," Dr. Roselli explains.

A third scenario involves patients who present with considerable aortic disease but in whom the need for complete repair is not pressing. In these cases, part of the descending aorta is repaired with a stent graft, with a plan to later complete the repair with an open operation as the disease progresses, thus buying the patient time before undergoing such major open surgery.

Regardless of the scenario, all types of ultra-hybrid repair have two things in common: the combination of endovascular and open components as well as some degree of staging, although the interval between stages can range from a week to more than a dozen years.

Staging is important for limiting trauma and its associated risks, particularly neurologic risks. "Staging the repair allows the spinal cord to adapt to the new anatomy and blood flow pattern, thereby reducing the risk of spinal cord injury, which is elevated with open repair of the descending aorta," Dr. Roselli says. "Also, staging the repair into endovascular and open components shifts the large open repair to a lower part of the chest, which reduces trauma to the lungs. That's important because many patients with extensive aortic disease have chronic obstructive pulmonary disease or other pulmonary risks."

Profile of cases and outcomes to date

Dr. Roselli and his colleagues have gleaned these insights on ultra-hybrid repair from the series of 92 patients he presented at the AATS meeting, representing the full Cleveland Clinic experience with the procedure from 2006 through the end of 2020. "This is the world's largest experience by far," he says.

Figure 1. Images from two key points in ultra-hybrid repair: post-TEVAR (left) and post-TAAA completion (right).

Overall, the patients were relatively young, with a mean age of 57.6 years. About two-thirds were men, and about one-third had a known connective tissue disorder, most often Marfan syndrome or Loeys-Dietz syndrome. Indications for repair were predominantly chronic dissection (63%) or aneurysm (30%), with the remainder of patients having an endoleak or acute type B dissection.

Across the cohort, first-stage endografting involved TEVAR in 75% of patients, frozen elephant trunk repair (FET) in 5%, and both TEVAR and FET in 20%. Distal anastomosis at the TAAA was infrarenal in 58% of cases, at the bifurcation in 29%, iliac in 8% and suprarenal in 5%.

In-hospital outcomes were as follows:

- 5 operative deaths (5.4%)
- 8 tracheostomies (8.7%)
- 18 cases of renal failure requiring dialysis (19.6%)
- 6 cases of permanent paralysis (6.5%)

"These are reasonable outcomes in view of what an extraordinarily high-risk population this is — people who need to have their whole aorta replaced," Dr. Roselli notes.

Over the longer term, survival at five years was 71% and freedom from reoperation at four years was 65%. "We found that renal dysfunction was associated with a higher risk of death," Dr. Roselli says.

Also notable was a strong trend toward more ultra-hybrid repairs over time, with annual volumes steadily rising from one case in 2006 to 19 cases in 2020. "These cases now represent about half of all thoracoabdominal aneurysm repairs we perform annually," Dr. Roselli observes.

Next steps in an evolving approach

While the above results are being prepared for journal publication, the Cleveland Clinic team hopes to soon perform a matched comparison between its ultra-hybrid repair patients and similar historical patients who have undergone open type 2 TAAA repair in terms of mortality, renal dysfunction, spinal cord injury and other outcomes. "There's not a perfect comparison group," Dr. Roselli says, "but we think this is the most reasonable match."

The team also expects to soon use a new surgical graft with a cuff specially designed to address the size discrepancies with previously placed stent grafts that are frequently encountered in these ultra-hybrid repairs. Terumo Aortic developed the new cuffed graft with specifications based on Cleveland Clinic patient data. It is expected to be cleared for commercial use later this year.

Figure 2. Successive stages of the ultra-hybrid approach to thoracoabdominal aortic aneurysm repair.

Advice for referral and lifelong management

Dr. Roselli says only a handful of U.S. centers have performed more than a few ultra-hybrid TAAA repairs and that it's worth directing likely candidates to one of these experienced centers, in view of the high risk of this patient population.

"Candidates would include almost anyone with a previous thoracic stent graft that's well seated and who has progressive aortic disease beyond the graft," he notes, adding that the best candidates may be those with previous open surgery in the left chest and patients with moderate but not severe lung compromise. "But it's generally applicable to most patients who have had earlier endovascular thoracic aorta treatment and now have progressive pathology in the descending aorta."

Recognizing the chronic nature of thoracic aortic disease is key, he emphasizes. "Once a patient has an aneurysm or dissection, it's important to realize their thoracic aortic disease is not going away," he says. "My top advice to providers is that lifelong regular imaging follow-up is absolutely critical for all patients with thoracic aortic disease. Even if you've fixed an aneurysm or dissection and it looks great at first, recognize that the disease is apt to progress as the patient survives. Everyone needs lifelong imaging." ■

Contact Dr. Roselli at 216.444.0995.

Over 18 Years of Cultivating Cardiovascular Program Improvement, the One Constant Is Change

Fostering a culture of continuing improvement is central to HVTI Advisory Services offerings

Achieving clinical excellence is of limited value without parallel attention to *sustaining* clinical excellence. That's a major emphasis of the counsel and guidance that the Advisory Services team of Cleveland Clinic's Heart, Vascular & Thoracic Institute (HVTI) has been providing to external hospitals and healthcare organizations since 2003.

"Our approach is centered around how an organization can sustain excellence through fostering a culture of change," says Suma Thomas, MD, MBA, Vice Chair of HVTI Strategic Operations, who directs the Advisory Services team. "We have learned that is one of the most essential ingredients for organizational success over our 18 years of providing these services."

Notably, those 18 years of experience represent two-thirds of the 27 consecutive years that Cleveland Clinic's HVTI has been recognized as the nation's No. 1 cardiology and heart surgery program by *U.S. News & World Report*. "Over the years, Cleveland Clinic has recognized that helping other organizations achieve clinical excellence in cardiovascular care through the sharing of processes and best practices is an ideal way to foster our excellence by continually working to address new challenges," notes Dr. Thomas.

The who and what of HVTI Advisory Services

The HVTI Advisory Services team is at the heart of those efforts. For nearly two decades, this multidisciplinary group has helped external healthcare organizations — hospitals/health systems and outpatient practices with employed, independent or mixed provider models — improve their clinical and operational performance and enhance care value.

The work of HVTI Advisory Services is carried out by a 20-member core team supported by cardiologists and surgeons across Cleveland Clinic's HVTI. The core team consists of HVTI physicians, nurses, quality analysts, continuous improvement specialists, clinical consultants, project managers and administrative directors. All have many years of experience in diverse areas of cardiovascular care and operations at Cleveland Clinic.

"Our team of consultants leverages their deep knowledge and experience to provide affiliate hospitals with well-rounded recommendations in a variety of areas," notes Edward Soltesz, MD, MPH, Director of Cardiac Surgery Affiliate and Alliance Programs.

Overall, HVTI Advisory Services are designed to help organizations' cardiovascular programs achieve high-quality outcomes, optimize efficiency and resource allocation, develop and enhance their existing programs, and expand their services if desired. "We offer advice and education on patient care, strategic planning and clinical innovation," says Dr. Thomas. "The goal is to help organizations realize a better return on cardiovascular investments for their patients, their institution and their community."

The foundation: Comprehensive service line assessment

For external programs, this collaboration generally begins with a comprehensive cardiovascular service line assessment by the HVTI Advisory Services team. Team members do on-site visits of the external program to conduct interviews, assess facilities, and observe procedures and surgeries. They also review the program's cardiology and cardiothoracic surgery registry data as well as operational processes.

"It's a deep dive into all aspects of the service line — covering cardiac surgery and various cardiology subspecialties such as electrophysiology, imaging, interventional and more," explains Dr. Thomas. Areas assessed range from quality infrastructure — such as clinical outcomes and registry practices — to clinical care delivery issues like staffing and patient experience. Also assessed are cost containment methods — supply chain management and resource utilization practices — as well as programmatic strategy matters such as strategic planning, regionalization, and marketing and branding.

The assessment process typically takes four to six months and culminates in two main deliverables: a pair of webinars (one administrative and one clinical) for discussing findings and recommendations, and a final report identifying program strengths and prioritized opportunities for improvement. The latter includes specific recommendations for direct solutions and how to bring them about. "It's an extensive clinical, quality and operational review of all areas of the service line," says Dr. Thomas.

All about options

Service line assessments are the most popular Advisory Services offering in recent years, with at least 65 such assessments completed to date. They provide the recipient organization with a road map for ongoing improvement and also offer options to continue working with Cleveland Clinic's HVTI. Some hospitals choose to engage the HVTI Advisory Services team to work with them to implement the recommendations, typically over a period of six months to a year.

Some organizations choose to build on their assessment by entering into an affiliation with Cleveland Clinic's HVTI. An affiliation is a long-term (five to seven years) co-branded relationship that an organization can undertake with Cleveland Clinic if it meets certain quality standards and has a demonstrated culture of change and improvement. The Advisory Services team works with affiliates to implement specific solutions for clinical, quality or operational challenges identified in their initial assessment (see sidebar at right for examples). Additionally, affiliates enjoy access to Cleveland Clinic's protocols and policies, second opinions, Grand Rounds and other CME events, data and registry boot camps, executive and leadership education, on-site observations and more.

As of mid-2021, HVTI had 10 hospitals active in affiliations across the U.S. These include five organizations that renewed their prior long-term affiliations over the past year. "These affiliation renewals demonstrate that our Advisory Services team has effectively modified our offerings over time to ensure that affiliation with Cleveland Clinic offers enduring value beyond the initial five- to seven-year term," says Dr. Thomas. "That is gratifying because it's a testament to a successful culture of change." ■

For more information on HVTI Advisory Services, email Amanda Lesesky at leseska@ccf.org.

A Sampling of Affiliated Programs' Success Stories

Mastering data management: St. Luke's Hospital in suburban St. Louis worked with Cleveland Clinic a few years ago to fine-tune its data management practices for its cardiovascular registries. Soon after adopting some recommended tools and implementing process changes, St. Luke's achieved a three-star overall quality rating for coronary artery bypass graft (CABG) surgery from the Society of Thoracic Surgeons — a remarkable feat, given that St. Luke's performed fewer than 200 CABG operations annually. St. Luke's believes the registry management revisions contributed to the stellar rating.

› **More at ccf.org/affiliateregistry.**

Second-opinion case review: An affiliated program sought a second opinion from Cleveland Clinic cardiac surgeons on management of a patient with a rare cardiac tumor in the right ventricle immediately below the tricuspid valve. Despite this unsettling tumor location, joint review of imaging studies and surgical strategy by the affiliate and Cleveland Clinic surgeons resulted in a successful surgery and patient recovery.

› **More at ccf.org/hvti-secondopinion.**

Making the most of M&M conferences: When leaders at Deborah Heart and Lung Center in southern New Jersey learned how Cleveland Clinic had evolved its cardiovascular morbidity and mortality (M&M) conferences in recent years, they engaged Cleveland Clinic HVTI physicians to share and explain the changes. After virtual meetings and sharing of HVTI's M&M guidelines, forms and dashboards, Deborah Heart and Lung Center restructured its own M&M conferences to promote use of objective metrics and a focus on nonpunitive, constructive discussion around quality improvement. Staff engagement in M&M conferences has since soared.

› **More at ccf.org/hvti-mm.**

Continuous quality improvement: A recent HVTI Advisory Services review of cardiovascular service line assessments at more than 20 U.S. hospitals found widespread opportunities for efficiency improvement and cost reductions in three major areas: turnaround times in catheterization labs, operating room (OR) utilization, and scheduling of OR nurse start times to better align with OR case times.

› **The analysis is detailed at ccf.org/hvti-affiliate-ci, and case studies of affiliate improvements in these realms are at ccf.org/cathlabefficiencies and ccf.org/eplabefficiencies.**

CME PREVIEW

Cleveland Clinic In-Person CME Returns With Crowd-Pleaser on Aortic Valve Disease

Mastering the Management of Aortic Valve Disease: Imaging, Intervention & Innovation

Friday - Saturday | December 3 - 4 | 2021
JW Marriott Essex House, New York City
Also offered via livestream

Cleveland Clinic is returning to in-person cardiovascular CME in early December with simultaneous in-person and livestream offerings of one of its most popular courses at its traditional venue in midtown Manhattan.

The latest iteration of "Mastering the Aortic Valve" will explore the full landscape of issues cardiologists and cardiac surgeons encounter in aortic valve disease care in 2021, with particular attention to imaging, intervention strategies, and recent and emerging innovations.

"Management of aortic valve disease has been fast evolving, which has altered the clinical framework for approaching valve disease quantification and treatments," says course director Lars Svensson, MD, PhD, Chair of Cleveland Clinic's Heart, Vascular & Thoracic Institute. "The result has been some confusion about optimal management strategies. In this course, national experts will synthesize and apply the most recent evidence on a multitude of questions in aortic valve disease care to address widespread gaps in knowledge and practice."

A faculty of 14 cardiologists and cardiac surgeons from Cleveland Clinic and three other top U.S. medical centers will address those gaps across a day and a half of instruction (all day Friday plus Saturday morning). The course is briskly paced, consisting of 10- or 15-minute presentations across the following five broad sessions, each capped off with a Q&A-based panel discussion.

Session I: *Contemporary framework for approaching aortic valve disease.* The course launches with a variety of big-picture perspectives, from trends in surgical and transcatheter aortic valve replacement (SAVR/TAVR) and medical therapy to Cleveland Clinic's approach to transcatheter management of aortic stenosis to the latest findings on TAVR practice from the TVT Registry. A centerpiece is a review of the recently updated American College of Cardiology/American Heart Association guideline for managing patients with valvular heart disease.

Session II: *Basic to advanced techniques for imaging the aortic valve.* This session uses five separate case-based presentations to explore the utility of various imaging modalities and approaches in the care of aortic stenosis, aortic regurgitation and bicuspid aortic valve. Additional segments address issues such as imaging considerations for the lifetime management of aortic stenosis.

Session III: *Controversies and difficult scenarios.* All of Friday afternoon is devoted to some of the hottest topics in aortic valve care, such as SAVR versus TAVR for low-risk patients with severe aortic stenosis, anticoagulation after bioprosthetic valve replacement and TAVR, and transcatheter valve-in-valve approaches versus redo SAVR. Additional presentations explore challenges beyond the scope of many aortic valve discussions, such as mixed aortic disease versus pure aortic stenosis, endocarditis requiring surgery and TAVR outcomes in patients with mitral valve disease.

Session IV: *TAVR.* Saturday kicks off with a well-paced review of a dozen different aspects of TAVR-related practice that too often go unaddressed in other courses, from stroke risk and cerebral protection to complications during and after TAVR to selection of devices for TAVR.

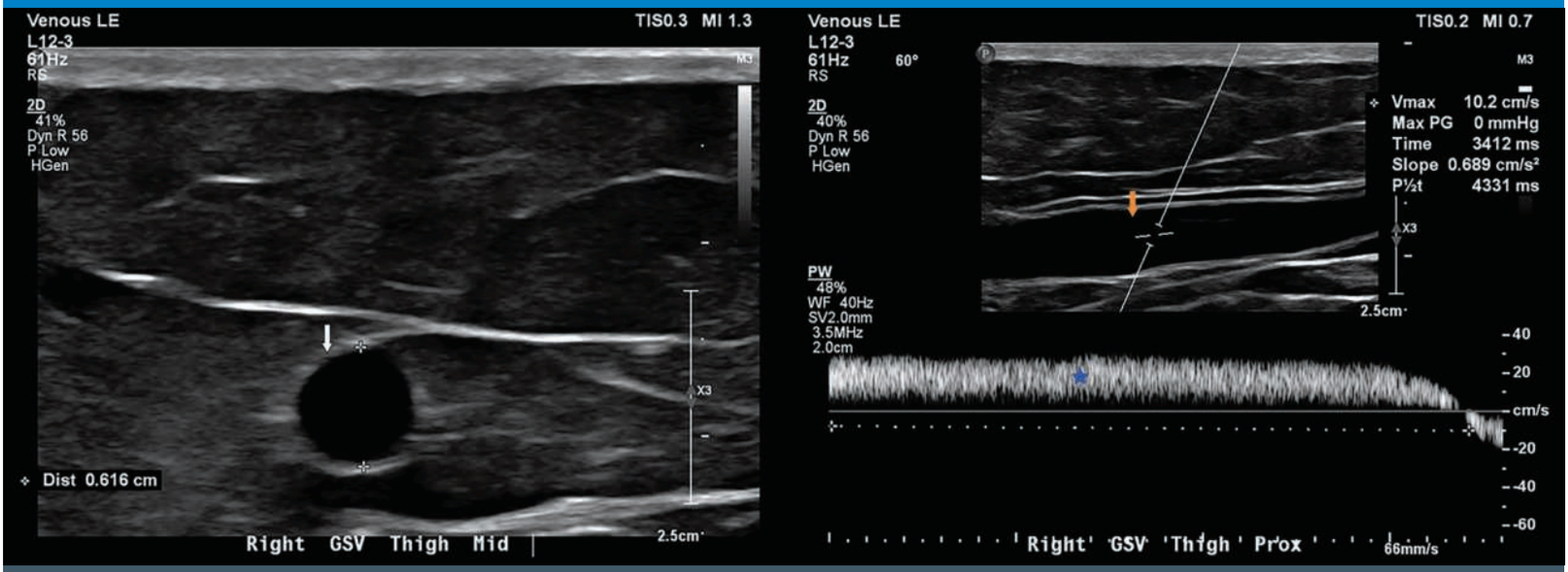
Session V: *Emerging technologies.* The course concludes with a number of forward-looking presentations covering everything from the use of support devices in aortic stenosis to a review of optimal post-TAVR hemodynamics to updates on the multicenter COMMENCE and PROACT Xa trials assessing potential advancements in SAVR strategies.

"We have been offering our 1.5-day 'Mastering the Mitral Valve' and 'Mastering the Aortic Valve' CME courses for several years now, with enthusiastic responses from participants," says Dr. Svensson. "These events are an ideal way for cardiovascular clinicians to keep up to date with the latest in valve care in a manner that is both comprehensive and efficient. And this year's simultaneous in-person and livestream options mean providers everywhere can benefit." ■

For more details and registration, visit ccfcme.org/aorticvalve21. Different registration fees apply to the in-person and livestream options; early-bird rates are offered through Oct. 4.

image OF THE ISSUE

VOLUME-BASED EXPERTISE IN COMPLEX VENOUS WOUND CARE



› **(Below)** Section of Vascular Medicine staff physician Geoffrey Ouma, DO, tends to a patient's lower extremity venous wound. **(Above left)** A representative short-axis grayscale ultrasound image showing venous insufficiency of the great saphenous vein (white arrow). Note the dilated vein, which is considered a varicose vein. **(Above right)** Example of a longitudinal grayscale image (orange arrow) of the same varicose vein showing valvular incompetency as a function of reversal of venous flow (blue star). This phenomenon often leads to nonhealing leg venous ulcers.

Cleveland Clinic is home to the largest and busiest noninvasive vascular laboratory in the U.S., with more than 2,220 clinical vascular imaging studies performed monthly. These studies include duplex venous ultrasonography for assessing lower extremity venous obstruction, venous insufficiency, varicose veins or venous valvular reflux disease, all of which can lead to delayed venous wound healing.

Besides serial debridement and wound bed preparation, our vascular medicine physicians use various wound dressing materials to absorb wound drainage and mobilize cellular matrix to promote wound healing. Additionally, multilayer compression garments are commonly used for patients with venous wounds to reduce leg swelling and venous hypertension.

Our vascular medicine specialists also collaborate with their vascular interventionalist colleagues to help restore arterial flow to the leg in cases of arterial obstruction and to employ endovenous laser ablation to treat varicose veins associated with venous leg wounds. ■

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Mastering the Management of Aortic Valve Disease: Imaging, Intervention & Innovation

Friday - Saturday | December 3 - 4 | 2021
JW Marriott Essex House, New York City
Also offered via livestream
Information/registration: ccfcme.org/aorticvalve21
(see page 18 for a detailed preview)

These activities have been approved for *AMA PRA Category 1 Credit™*.