

Annual Report 2021

Innovations in Cardiovascular Health



KNIGHT
CARDIOVASCULAR
Institute



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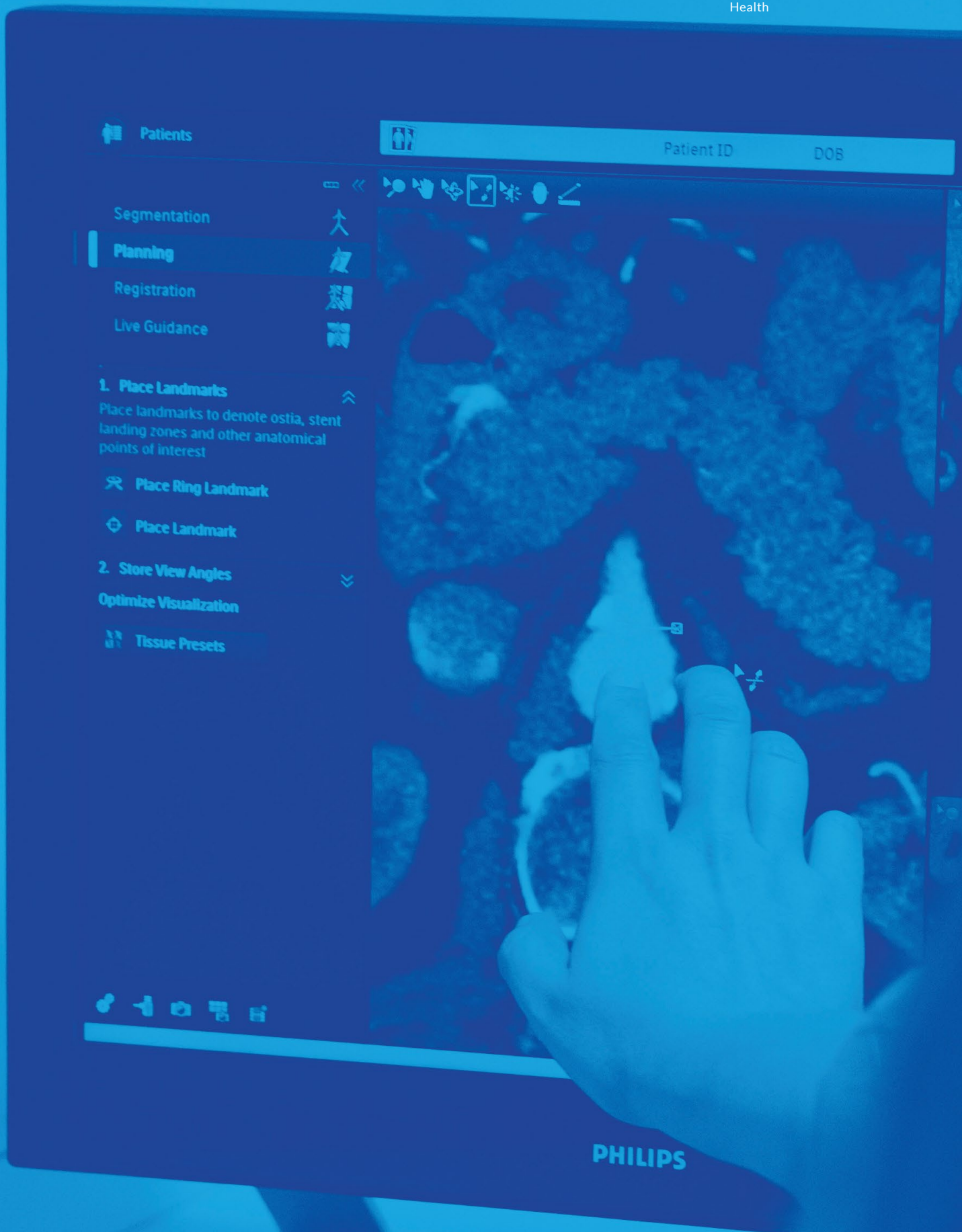
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Providing a continuum of comprehensive care

Oregon's only public academic health center

Based in Portland, we have more than one million patient visits each year. We operate the top-ranked adult and children's hospitals in Oregon, and secure competitive research funding of nearly \$400 million. As a public corporation serving the best interests of Oregon and the region, we also provide services to the most vulnerable Oregonians as well as outreach that improves health in communities across the state.



Research

\$586M OHSU award dollars

\$129M+ Funding focused on clinical trials

100/201 In 2021, OHSU disclosed 100 new inventions and filed 201 patent applications.

#42 World's Most Innovative OHSU ranks No. 42 on the *Reuters 100: The World's Most Innovative Universities 2019*.

Top 20 Innovation Ranking OHSU placed in the top 20 of *Nature's Index 2017* Innovation ranking, which measures the quality and quantity of research by institutions and universities worldwide.




Education

OHSU helps educate over 5,400 students and trainees each year.

Community service

OHSU has more than 200 community health care programs, reaching out to vulnerable groups in urban areas as well as underserved rural communities throughout the state. In 2021, OHSU had a community benefit contribution of \$522 million.



Facilities and employees

19,136 Employees

400 acres OHSU owns and leases space beyond its campuses. Altogether, OHSU occupies more than 8.7 million square feet on about 400 acres.

OHSU Knight Cardiovascular Institute

Top-ranked heart hospital

An evidence-based institute, we are dedicated to creating new ways to approach cardiovascular disease from every angle at every point in a person's lifetime. We are organized around the principle that the integration of clinical care and research expands possibilities for cardiovascular health. As Oregon's only comprehensive heart program, our patients have access to the latest drug treatments, surgery techniques and advanced diagnostic tests.

Physicians

110 Clinical faculty

29 Fellows



Research funding

13

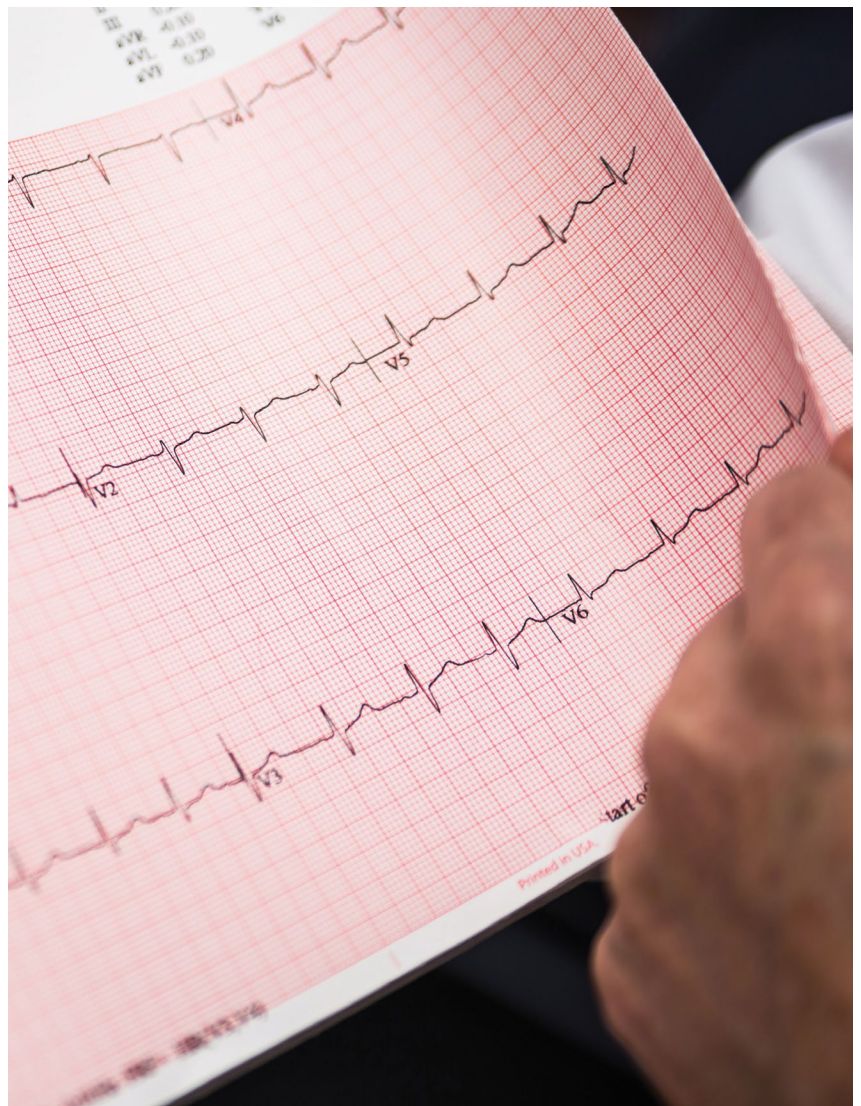
Researchers

113

Clinical trials

\$7.4

Million in research funding



Quality, outcomes and awards



First-ever DNV Cardiac Center of Excellence DNV GL certification combines national and international standards, including those from the U.S. Centers for Medicare and Medicaid Services and the International Organization for Standardization.



MAGNET The American Nurses Credentialing Center designates OHSU as a Magnet hospital, the highest recognition a nursing program can receive. Just 6% of U.S. health care organizations hold this designation that acknowledges having highly qualified nurses, physicians and specialists, fostering collaboration across disciplines and improving patient care through high standards.



American Heart Association Get With The Guidelines Gold Plus



American Heart Association Get With The Guidelines Mission: Lifeline Bronze Plus STEMI and Bronze NSTEMI Awards

vizient

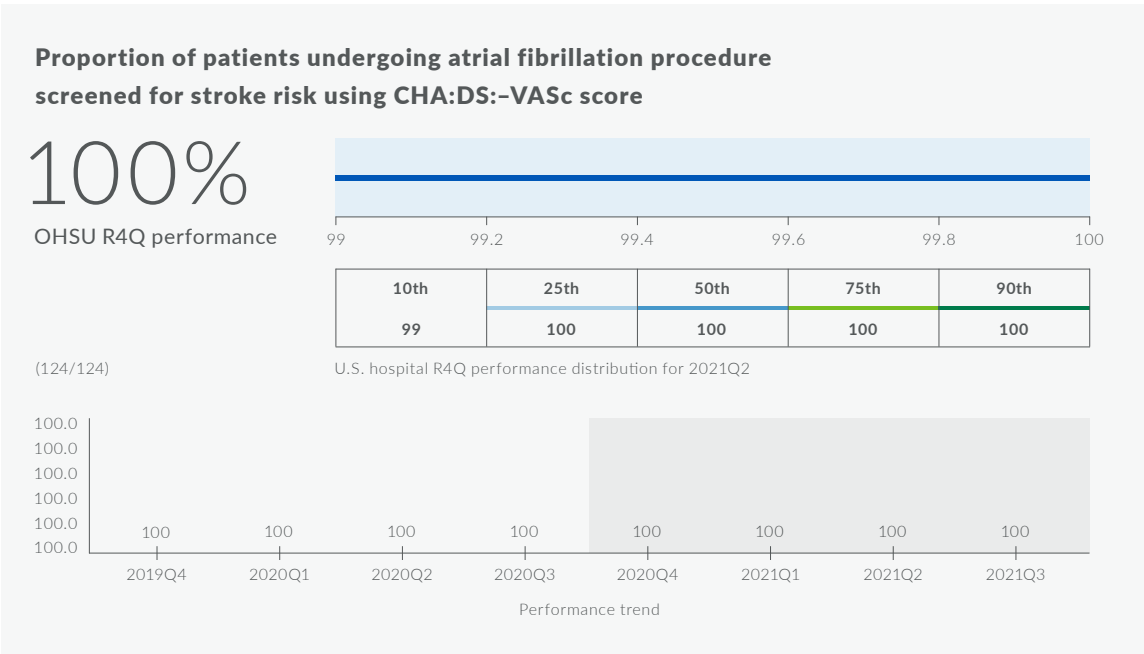
VIZIENT The nation's most respected health care performance organization ranks OHSU in the top 12 academic medical centers for quality and accountability measures, including safety, mortality, clinical effectiveness, efficiency and patient centeredness.



OHSU ranks among the best hospitals in the country and No. 1 in Oregon.

AFib Ablation Registry

OHSU Knight Cardiovascular Institute participates in the American College of Cardiology’s AFib Ablation Registry for the purpose of using data to support evidence-based procedure success and patient outcomes.



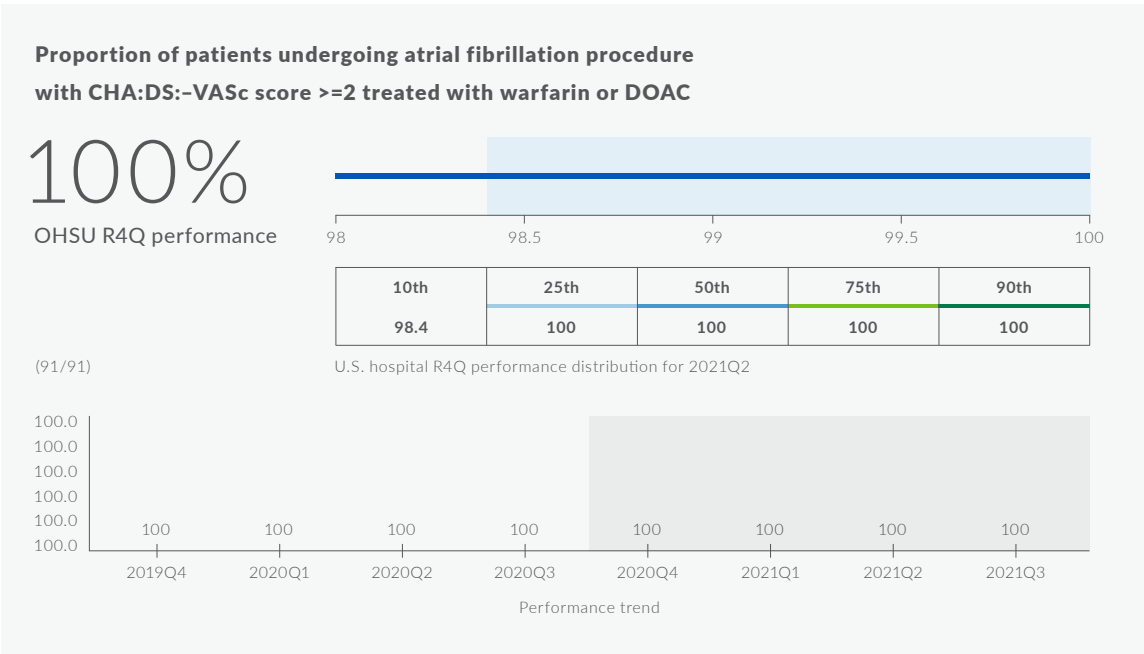
0%

Observed mortality
Top quartile for all hospitals in the registry



0.6%

Disabling bleeding
Top quartile for all hospitals in the registry



Expanding possibilities for cardiovascular health across clinical care and research



Fred Tibayan, M.D. (from left), surgery director of the Heart Failure and Transplant Program, confers with cardiologists Luke Masha, M.D., M.P.H., Johannes Steiner, M.D., and Nalini Colaco, M.D., Ph.D., and with nurse and Heart Transplant Coordinator Heather Miller-Webb. Not only do OHSU providers excel at clinical care, but they are deeply immersed in discovering the precursors of cardiovascular disease.

From studying developmental and preventive influences on disease to pioneering minimally invasive therapies to enhance graceful aging, OHSU Knight Cardiovascular Institute is working in all aspects of cardiovascular health.

Our focus on health and science creates a unique environment where new ideas take root and barriers continue to be broken. With a strong tradition of diverse, interdisciplinary teams, we believe OHSU Knight Cardiovascular Institute's breadth and depth is ideal for advancing human cardiovascular health.

Despite the challenges of the pandemic, our faculty has provided leading-edge clinical care and even performed first-ever procedures for heart valves. We are always seeking new opportunities to improve patient care through collaboration, whether that is comanaging patients in the CVICU, bringing pulmonary hypertension under the heart failure umbrella or seeking less invasive solutions in hypertrophic cardiomyopathy.

We are also well known as a hub of discovery, constantly pushing boundaries. Our research has a track record of transforming human health locally and globally. We are studying the mechanisms of cardiovascular disease, from molecules to models to clinical trials. As the only academic health center in Oregon, we are committed to translating breakthroughs for better health for Oregonians and people far beyond our borders.

Continuum of Care



Across the life span Our clinicians are investigating cardiovascular disease from before birth and through old age, providing acute clinical care throughout.

Across the translational continuum Our clinicians are also scientists, producing meaningful and far-reaching results.

Across the spectrum of disease From cardiogenetics and preventive cardiology to cardiac rehabilitation, we deliver the broad range of care that transforms lives.

**Co-director of the Complex
Heart Valve Program Firas Zahr,
M.D.**, is a leader in minimally
invasive heart valve therapies.

Innovations
in Cardiovascular
Health

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Delivering leading- edge clinical expertise

Trailblazing work in structural heart therapies

OHSU Knight Cardiovascular Institute is on the front line of pioneering every type of valve disease therapy and has achieved excellent outcomes. OHSU remains the only center in Oregon that can repair or replace all four heart valves percutaneously.

In 2021, our surgeons further advanced the field by participating in the latest trials and demonstrating techniques for an international audience.

“To be at the forefront of evolving therapies is exciting,” said Howard Song, M.D., Ph.D., co-director of the OHSU Complex Heart Valve Program. “We’re part of a new era of science that is extending life and lowering the surgical burden for patients. We are proud to contribute to expanding options for all aspects of heart valve disease.”

Advancing TMVR therapy for mitral valve replacement

Firas Zahr, M.D., the director of Interventional Cardiology and co-director of the OHSU Complex Heart Valve Program, announced the results of the Early Feasibility Trial for Intrepid Transcatheter Mitral Valve Replacement System with Transfemoral Transseptal Approach at the Cardiovascular Research Foundation’s Transcatheter Cardiovascular Therapies symposium in November. OHSU was the highest enroller for this trial, which saw no mortalities. Average procedure time was 46 minutes, and patients stayed in the hospital for less than a week.



Firas Zahr, M.D., (left) and Howard Song, M.D., are co-directors of the Complex Heart Valve Program.

They were part of the team that performed the first transcatheter transfemoral tricuspid valve replacement in a living person.

“All patients in the trial have their disease cured with no more mitral regurgitation,” Zahr said. “Because we only need a small incision in the groin, we are able to treat a broader range of patients than ever before. This new method provides more options for this common condition.”

With these results, transfemoral access will roll into the APOLLO trial of TMVR patients with severe mitral regurgitation, which uses transapical access. Study investigators will now have another access route that could present less risk to patients during the procedure. The trial is already in the pivotal stage. In February 2020, an OHSU Knight Cardiovascular Institute team led by Zahr, Song and Scott Chadderdon, M.D., implanted the first Medtronic Intrepid mitral valve via the transfemoral transseptal approach. Many national and international physician experts were present for the historic moment.

Leading education on the international stage

The Cardiovascular Research Foundation tapped OHSU to perform three live cases for the Transcatheter Valve Therapy Structural Heart Summit in July 2021. (Due to pandemic precautions, the surgeries were prerecorded rather than livestreamed but have since been viewed by a large global audience.) OHSU was one of six U.S. centers invited to perform live cases.

OHSU faculty performed cases and led discussion on the following topics/procedures:

- Transcatheter therapies for surgical bioprosthetic valve failure
- Transfemoral transcatheter mitral valve replacement
- Treatment options for bicuspid aortic stenosis

Changing possibilities in aortic and tricuspid regurgitation

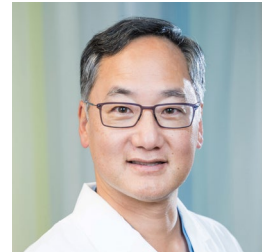
The OHSU Heart Valve Center is the only center in Oregon participating in the clinical trial of the JenaValve,* a transcatheter heart

valve technology designed for both aortic stenosis and regurgitation. Until now, there has not been a percutaneous therapy for aortic regurgitation.

“As many of these patients are not suitable for surgical interventions and traditional transcatheter aortic valves are not fitted for aortic regurgitation, this option is unique for this patient population,” Song said.

In 2020, an OHSU Knight Cardiovascular Institute team led a unique moment in human history — the first transcatheter transfemoral tricuspid valve replacement in a living person. The first tricuspid valve repair patient was part of the CLASP II TR clinical trial using the Edwards Lifesciences’ PASCAL transcatheter valve repair system,* and the first tricuspid valve replacement was performed using the Edwards Lifesciences’ EVOQUE* valve as part of the TRISCEND trial. Since then, OHSU Knight Cardiovascular Institute has performed more than two dozen of these procedures successfully.

*Investigational device not for sale in U.S.



“We’re part of a new era of science that is extending life and lowering the surgical burden for patients. We are proud to contribute to expanding options for all aspects of heart valve disease.”

Howard Song, M.D., Ph.D., co-director of the OHSU Complex Heart Valve Program



Options for all four heart valves

The OHSU Complex Heart Valve Program offers every form of percutaneous and surgical intervention for heart valve repair and replacement, including the latest clinical trials:

- Transcatheter mitral valve repair with PASCAL system
- Transcatheter mitral valve replacement with Intrepid device
- Transcatheter tricuspid valve repair with PASCAL system
- Transcatheter tricuspid valve replacement with EVOQUE device
- Transcatheter mitral valve replacement with EVOQUE EOS device

Broadening clinical treatment in advanced heart failure

The Heart Failure and Transplant Program of the OHSU Knight Cardiovascular Institute delivers outstanding and comprehensive care for patients who have some of the most challenging clinical problems in cardiovascular health.

Providing less surgical burden and more telemedicine support for LVADs

OHSU Knight Cardiovascular Institute has the highest volume of left ventricular assist device (LVAD) implantations in Oregon and the second highest volume in the Pacific Northwest. With the high volume, our outcomes are above the national average as reported through the INTERMACS registry, with an average one-year survival rate above 90%. Instead of open sternotomy, our surgical team places most mechanical heart pumps through a lateral thoracotomy approach, reducing overall length of stay and decreasing complication burden.

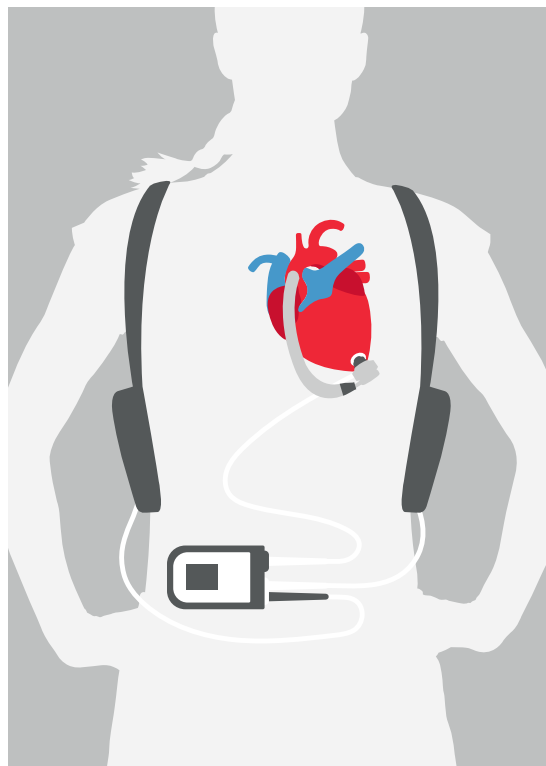
Many patients come to OHSU Knight Cardiovascular Institute from other states and long distances. Our LVAD specialists use a broad variety of platforms to improve patient outcomes while minimizing the risk for infectious transmissions.

These platforms include virtual ICU monitoring and virtual visits in a shared care model with local cardiologists as well as remote monitoring of all LVAD-specific parameters through ActiCare Health VAD monitoring. LVADs are placed in patients that have advanced heart failure either as a bridge to transplantation or as stand-alone long-term therapy when transplantation is not the best option for the patient. The purpose of the program is to improve both patient survival and improve quality of life for those patients electing to have an LVAD implanted.



90%

Average one-year survival rate after LVAD implantation at OHSU



With the 2018 changes in transplant allocation, LVADs are no longer the preferred bridge to transplant that they once were at OHSU and nationwide; however, they can offer survival benefits almost identical to cardiac transplantation due to third-generation LVADs with enhanced efficiency, durability and smaller pump size. As of 2021, the HeartMate 3 is the only long-term LVAD approved by the Food and Drug Administration available for all indications. The pandemic has accelerated a shift toward telemedicine and virtual patient encounters for our LVAD patients across all corners of the state and beyond.

Initiating a Shock Consult Program

OHSU Knight Cardiovascular Institute is working collaboratively with providers throughout the state to provide a resource for shock patients that require a higher level of care. There is a trend nationally to move to earlier initiation of mechanical circulatory support. Here at OHSU, our cardiac catheter laboratory has expertise in implanting an array of these devices, and our multidisciplinary team has experience managing this patient population. When community providers contact our hospital about a cardiogenic shock patient, they can connect by phone within minutes to the “Shock Team.”

“If we get a call, the community hospital gets a lot of expertise in a short time, using a Heart Team approach,” said Deborah E. Meyers, M.D., the head of Heart Failure and Transplant Cardiology.



727

**Heart transplant
surgeries since 1988**

OHSU Knight Cardiovascular
Institute has the longest-
running heart transplant
program in Oregon.

The multidisciplinary “Shock Team” consult includes:



Heart failure
cardiologist



Interventional
cardiologist



Cardiothoracic
surgeon



Extracorporeal
membrane
oxygenation
attending



ICU attending

Building a robust, multidisciplinary Pulmonary Hypertension Clinic

The Pulmonary Hypertension Clinic team includes experts in pulmonology, cardiology, critical care, allergy and immunology. Combining this expertise and extensive resources, we offer our patients all available treatments for pulmonary arterial hypertension, ranging from oral to continuous parenteral therapies. Our team provides longitudinal outpatient care as well as inpatient consultative services for patients with pulmonary hypertension.

The Pulmonary Hypertension Clinic team has also established multidisciplinary partnerships to help manage frequently encountered comorbidities in pulmonary hypertension, including rheumatology and addiction medicine. Further, the pulmonary hypertension clinicians have an active research program, giving patients access to numerous clinical trials for pulmonary hypertension.

“We have experience with every therapeutic option for pulmonary hypertension, some of which can be very complex,” said Jeffrey Robinson, M.D., pulmonary and critical care specialist. “Coordinating our expertise and embracing a multidisciplinary model allows us to provide a personalized treatment plan for each patient to improve outcomes.”

Optimizing heart failure support for people without homes

The Recuperative Care Program for Heart Failure (RCP-HF) enrolled its first patient in February 2021. A collaboration between OHSU and a nonprofit community partner, Central City Concern, the program provides two months of transitional housing for heart failure patients experiencing housing instability. During the residential period, patients receive weekly visits from Jayne S. Mitchell, ANP-BC, CHFNP, who focuses on guideline-directed medical therapy for their heart failure. Additionally, there are on-site case managers, transitional housing specialists, a registered nurse, a pharmacy and a laboratory.

“Among our first 10 patients in the program, our results are encouraging,” Mitchell said. “The majority were managing their medications and had permanent housing plans at discharge.”

All but one of the patients in the first cohort is diagnosed with methamphetamine-associated cardiomyopathy.

“These are patients who lean heavily on the health care system, especially emergency departments,” Mitchell said. “Even so, they have poor outcomes. OHSU’s previous program provided three weeks of transition, but we found that 75% of patients didn’t attend follow-ups with our heart failure providers. These people were often discharged with the same lack of housing and unmanaged heart failure. No provider feels good about that.”



Mitchell credits Drew Grabham, LCSW, supervisor for Adult Inpatient Social and Transitional Care at OHSU, for designing RCP-HF. OHSU’s Care Management charity is the primary funding source for this program, with some Medicaid coordinated care organizations expanding their coverage for long-term referrals in this program. Readmission rates among the first cohort were 36% at 30 days and 54% at 60 days. Though that may be high compared to the general public, no data exists in this population for comparative purposes.

“Likely the readmission rate would be 100% for this demographic if it were tracked,” Mitchell said. “Instead, this feels like a win. These are people with a high symptom burden, suffering every day, who have all the additional issues housing instability brings. From the heart failure perspective, these eight weeks of support allow us to get their medical management settled and routine before discharge.”

The Recuperative Care Program for Heart Failure is a collaboration between OHSU and a nonprofit community partner, which provides two months of transitional housing for heart failure patients experiencing housing instability. The RCP-Blackburn housing building (above) in Portland combines an on-site health care clinic with housing.

The Recuperative Care Program for Heart Failure

Initial data of first cohort of 10 patients who completed the program.

Medication adherence (self-report)	82%
Guideline-directed medical therapy	100%
Adherence to weekly visits with NP	79%
Permanent housing plan at discharge	70%
Readmission to hospital 30 days	36%
Readmission to hospital 60 days	54%
Characteristics	
Age (mean)	43
Ejection fraction (mean)	26%
Etiology of methamphetamine-associated cardiomyopathy	90%
OHSU transitional team (C train/new directions)	100%



"These are people with a high symptom burden, suffering every day, who have all the additional issues housing instability brings. From the heart failure perspective, these eight weeks of support allow us to get their medical management settled and routine before discharge."

Jayne S. Mitchell,
ANP-BC, CHFN

Pioneering therapies in hypertrophic cardiomyopathy

The first and only multidisciplinary clinic in the Pacific Northwest dedicated to treating this complicated disease, the Hypertrophic Cardiomyopathy Clinic at OHSU Knight Cardiovascular Institute is a Center of Excellence certified by the Hypertrophic Cardiomyopathy Association.

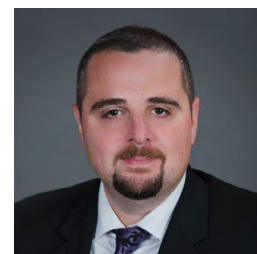
Our integrated HCM team of experts from cardiology (imaging, interventional, electrophysiology, pediatric and surgery) and medical genetics provides clinical care across the life span.

Further, OHSU is participating in 10 ongoing clinical trials in HCM and has the highest enrollment in most of these trials. These new therapies are bringing hope to patients and families with the promise of treating the underlying disease. For example, some OHSU patients enrolled in the PIONEER-OLE (an open-label extension of mavacamten for obstructive HCM) have cardiac imaging evidence of positive remodeling with regression in heart thickness and mass.

Entering 2022, the clinic will be participating in three additional trials:

- The phase 3 SEQUOIA-HCM trial of aficamten in patients with obstructive hypertrophic cardiomyopathy.
- The phase 2 REDWOOD-HCM Cohort 4 trial of aficamten in nonobstructive hypertrophic cardiomyopathy.
- A gene therapy program targeting mutations in MYBPC3 proteins, which are responsible for 30–40% of sarcomeric HCM cases.

Because HCM is drastically underdiagnosed, another area of research is finding highly predictive biomarkers that could identify predisposition for HCM. OHSU has a comprehensive biobank of tissue and blood donated by HCM patients for research. This resource is key to investigative efforts into the mechanisms of the disease, response to therapy and identification of biomarkers.



"Our efforts are focused on transforming HCM to a medically treatable disease. For this reason, we are heavily involved in the science to push this agenda forward and find alternative therapies."

Ahmad Masri, M.D., M.S.,
director of the Hypertrophic
Cardiomyopathy Clinic



45

**Unique subjects
treated as of 2021**

A robust research program runs in parallel with comprehensive clinical care. OHSU was instrumental in progressing the selective cardiac myosin inhibitor mavacamten (currently undergoing Food and Drug Administration review) through the clinical phases of development. Globally, OHSU has the largest and longest active cohort of patients on cardiac myosin inhibitors.

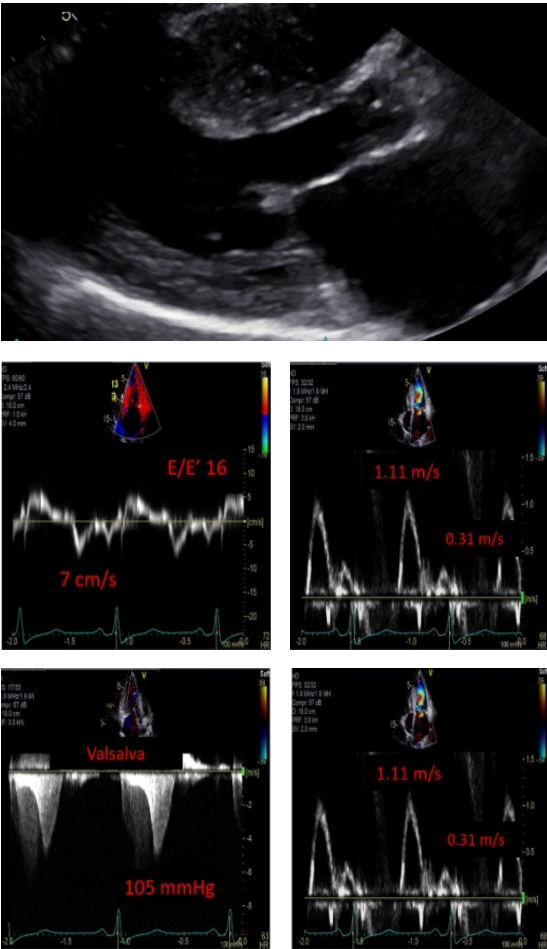


High-intensity ultrasound for HCM

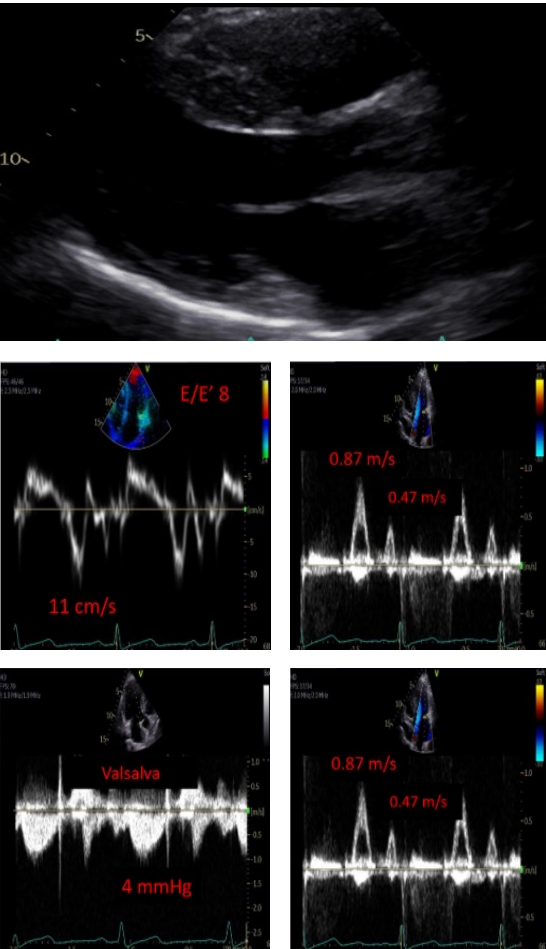
An area of promising research is septal reduction using precision ultrasound. The OHSU Translational Electrophysiology Laboratory is engineering a novel therapeutic high-intensity focused ultrasound catheter for clinical application in both ventricular arrhythmias and HCM. Preclinical studies are complete, with a first-in-human trial likely in 2022.

"We believe this technology will allow us to intervene at an earlier stage of the HCM disease process, which could lead to better outcomes," said electrophysiologist Babak Nazer, M.D., director of the lab.

Baseline*



Week 144*



Echocardiographic evaluation of a subject enrolled in PIONEER-OLE. A) Echocardiogram at baseline and B) Echocardiogram at 144 weeks of follow-up (except peak exercise LVOT gradient done at week 72).
*Baseline and Week 144 are both obtained from the parasternal long axis view at end diastole.

Variable	Baseline	Week 144
LVMI	168 g/m2	115 g/m2
LVWT (anteroseptal)	23 mm	14 mm
LVWT (inferolateral)	13 mm	8 mm
LVEF	75%	65%
LAVI	85ml/m2	35 ml/m2
NYHA class	II	I
NTproBNP	10,132 pg/ml	225 pg/ml

Transforming care in the time of COVID-19

As we enter the third year of a global pandemic, the OHSU Knight Cardiovascular Institute is not only providing leading-edge clinical care, but also contributing to the research literature about the impact of SARS-CoV-2 and the mechanisms affecting the cardiovascular system.

Pivoting CVICU clinical care

In addition to critical care, the attending intensivists at the CVICU have training in anesthesiology, emergency medicine, internal medicine or cardiology. This gives the team a depth and diversity in expertise that was crucial as the unit pivoted during the pandemic to care for additional patient populations.

With elective surgeries canceled or postponed, the CVICU saw increased acuity of patients needing emergency procedures. Simultaneously, the team leaped in to provide care for many critically ill patient populations typically cared for in other ICUs.

Early in the pandemic, this meant supporting patients experiencing the effects of delayed care. This included not only cardiovascular exacerbations for myocardial infarction and heart failure, but also patients with hematologic malignancies, chronic obstructive pulmonary disease and more.



The diversity of our ICU team also contributed significantly to patient care needs as COVID-19 cases swelled, standing up additional provider teams and even a new ICU in just a few days.

Despite the additional challenges of the past year, the CVICU continued to progress care for cardiovascular patients. As the OHSU Knight Cardiovascular Institute Structural Team continued to innovate and perform several first-in-human percutaneous valve interventions, the CVICU and Cardiac Anesthesia teams anticipated and adapted their care.

“While these patients have done very well, it is the job of the intensivist to be prepared for all the things that could go wrong, and this is magnified when the procedure has never been done before,” said CVICU Medical Director T. Miko Enomoto, M.D. “It’s exciting to help evolve therapies in new directions together.”

Heidi Paulson, RN, B.S.N., (left) and Miko Enomoto, M.D., try out new PAPR respirator lenses. The CVICU expanded care to patients with COVID-19 and other acute and chronic conditions during the height of the pandemic.

Collegiality and collaboration are the key elements to the distinctive success of this CVICU, Enomoto emphasized. For example, an advanced heart failure cardiologist and an intensivist co-round on every heart failure or mechanical device patient daily or more often.

“It’s people carving out time to be in the same place and review the same data together, so our treatment plans and goals are aligned for making complex and tailored patient care plans in real time,” she said.

Investigating strategies to characterize SARS-CoV-2

Quick diagnostic for mechanism of cardiac involvement

Jonathan R. Lindner, M.D., is principal investigator of a current study using novel noninvasive methods of imaging heart muscle blood flow at the bedside — including in the ICU — to rapidly assess problems with flow in patients with COVID-19. The purpose of the study is to characterize mechanisms of cardiac injury, one of the most critical pathobiological effects of the novel coronavirus.

Congenital heart disease

Lead author Craig S. Broberg, M.D., published the results of an investigation into whether COVID-19 has a higher impact on adults with congenital heart disease (CHD). The study involved more than 1,000 patients (roughly half male-to-female ratio) in 58 CHD centers worldwide.

The data showed that death from COVID-19 in CHD patients was commensurate with the novel coronavirus mortality rates in the general population and that anatomic complexity doesn’t impact the severity of infection. Patients with worse physiological stages, such as cyanosis and pulmonary hypertension, were more vulnerable to mortality and complications.

Prolonged arterial and venous thrombotic events

Primary investigator Khanh P. Nguyen, M.D., M.C.R., is conducting a pilot study to characterize the arterial and venous thrombotic risks of SARS-CoV-2 in patients with cardiovascular disease compared to the general population. Concentrating on the delta variant surge, Nguyen is collecting blood samples from both patient categories to characterize their coagulation and inflammatory profiles. She will then follow up at one year to determine if there are persistent long-term risks for thromboembolic events. Simultaneously, Nguyen is conducting a retrospective review of the incidence of venous thromboembolic events and cardiovascular events among patients with both cardiovascular disease and COVID-19 infections.

“By identifying short-term and long-term effects we hope to collect data that may be helpful for guiding prophylaxis or treatment for thrombosis as well as gauge the duration of therapy,” Nguyen said.



Khanh P. Nguyen, M.D., M.C.R., is conducting two simultaneous studies to characterize the arterial and venous thrombotic risks of SARS-CoV-2 in patients with cardiovascular disease.

Deborah E. Meyers, M.D.,
leads OHSU's comprehensive
Heart Failure and Transplant
Program team.

Innovations
in Cardiovascular
Health

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Clinical programs

Aortic conditions

Nationally and internationally recognized clinicians and researchers in vascular surgery, cardiothoracic surgery, interventional radiology, cardiovascular medicine and related disciplines partner to provide consultation, treatment and comprehensive surgical and medical management for any aortic condition. Services include the latest multimodality aortic imaging, medical monitoring, aneurysm repair, endovascular surgery, hybrid open/endovascular surgery and minimally invasive vascular surgery such as EVAR and TEVAR.

Cardiogenetics

This multidisciplinary team of experts provides personalized care and support to patients and families with hereditary cardiovascular diseases such as familial hypercholesterolemia, Marfan syndrome, familial amyloidosis, dilated and hypertrophic cardiomyopathy, and Long QT syndrome, among others. Genetic counselors, cardiologists, electrophysiologists, surgeons, neurologists, primary care providers, nephrologists, nurses and other health care providers work together to ensure patients receive precision health care tailored to their genetic diagnosis. Genetic counselors consult with patients and families to understand the hereditary nature of cardiovascular diseases, provide genetic testing, address the physical and emotional implications of having an inherited cardiovascular condition, and connect patients to research opportunities.

Cardio-oncology

This unique program specializes in the cardiovascular care of patients currently undergoing or previously treated with chemotherapy, radiation therapy or bone marrow transplantation. To ensure long-term health and overall survival from cancer, experts provide care for prevention of chemotherapy-induced cardiotoxicity and radiation-induced heart damage. They also provide management of existing heart conditions during cancer treatment and cardiac complications after cancer treatment, and assessment of long-term cardiovascular risk with optimization of preventive treatments for cancer survivors. The multidisciplinary program brings together cardiologists with a special interest in the cardiovascular effects of anti-cancer therapies and oncologists to provide comprehensive and personalized care for our patients.

Cardiothoracic surgery

We are a regional resource for patients with advanced heart diseases that require complex treatments. OHSU's cardiac surgery team cares for adult patients with congenital and acquired heart diseases, including coronary artery disease, valvular heart disease, aortic aneurysms and heart failure, using innovative surgical techniques. Minimally invasive approaches are used whenever possible to give patients the best outcomes while minimizing discomfort and recovery time.



Level 1

Trauma Center designation

Center for Preventive Cardiology

For patients with increased risk of heart disease (e.g., dyslipidemia, diabetes and hypertension), the Center for Preventive Cardiology offers a combination of advanced medical intervention and lifestyle modification. We work with genetic counselors, behavioral health experts and lipid experts to offer specialized care for patients with complex lipid abnormalities such as familial hypercholesterolemia, intolerance to statins, and early family history of premature coronary artery disease. Our multidisciplinary team includes endocrinologists, cardiologists and nutritionists, who together offer a team approach to managing other high-risk factors. The center also includes OHSU's three-phase inpatient/outpatient cardiac rehabilitation program, which is nationally certified by the American Association of Cardiovascular and Pulmonary Rehabilitation.

Congenital heart disease

Our program is comprised of a full-service team of adult, pediatric and interventional cardiologists, geneticists, psychologists and heart surgeons who specialize in the inpatient and outpatient care of adults with congenital heart disease, including the full spectrum from undiagnosed lesions to complex palliated patients. OHSU offers state-of-the-art diagnostics, catheter intervention, electrophysiologic study and cardiac surgery, and patients have access to congenital heart disease clinical trials not available elsewhere in the state.

Heart failure and transplant

OHSU is Oregon's largest and longest running heart transplant program. A multidisciplinary team of cardiac surgeons, cardiologists, intensivists, clinical coordinators, advanced practitioners and social workers specializes in the care of patients with advanced heart failure and works together to provide the most appropriate advanced therapies available, including augmented medical therapy, inotropes, ventricular assist devices and other forms of mechanical circulatory support, and heart transplantation. OHSU has performed more than 700 heart transplants and more than 200 mechanical support device implants.

Heart rhythm disorders

We offer a full range of electrophysiology procedures, including pacemaker and defibrillator implantation; electrophysiology study and ablation of supra-ventricular tachycardia, atrial fibrillation and ventricular tachycardia; laser lead extraction; and epicardial access and ablation. OHSU is the first hospital in the region to offer a cryoballoon procedure to isolate, freeze and ablate the pulmonary veins, and is the only hospital in the region with a research protocol that permits safe MRI scans on patients with a permanent pacemaker or implantable cardioverter defibrillator.

Hypertrophic cardiomyopathy

The first program of its kind in Oregon, this multidisciplinary team from cardiology, medical genetics and pediatric cardiology provides expert care for a condition characterized by abnormal thickening of the left ventricular muscle. The program is registered with the Hypertrophic Cardiomyopathy Association and provides treatment that includes medical therapies (beta blockers, certain calcium channel blockers, disopyramide), septal reduction therapies (surgical or catheter), implantable cardioverter defibrillators and advanced heart failure therapies.



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Institutions nationwide
recognized by the
Adult Congenital
Heart Association



1 of 43

Centers of Excellence
recognized by the
Hypertrophic
Cardiomyopathy
Association and the
only one in Oregon

Ischemic heart disease

Advanced medical, interventional, diagnostic and surgical procedures to manage diseases of the coronary arteries, including percutaneous coronary intervention and coronary artery bypass grafting. OHSU is home to Oregon's first accredited chest pain center and is one of the few hospitals in the country to offer myocardial contrast echocardiography to detect decreased blood flow quickly and accurately in arteries.

Maternal cardiac

Unique to the region, this clinical partnership between cardiology and maternal fetal medicine at OHSU provides comprehensive care for women with diagnosed or suspected cardiac disease who are pregnant or planning for a pregnancy. The program offers preconception counseling, cardiac monitoring during pregnancy and early postpartum follow-up. Wherever possible, the program partners with local providers to give the best ongoing care available to our patients.

Structural heart disease

A multidisciplinary team, including imaging specialists, interventional cardiologists, nurses, advanced practitioners and surgeons, provides a comprehensive approach to valvular heart disease, congenital defects and acquired cardiovascular conditions. Catheter and surgical approaches are available to patients with all types of valvular heart disease, hypertrophic cardiomyopathy, coronary arteriovenous fistulae and other acquired heart defects. For patients with a patent foramen ovale, joint evaluation by neurologists and cardiologists determines whether closure might reduce the risk of future stroke. Active clinical trials are available to patients for the treatment of many of these conditions. This comprehensiveness of our structural heart program results in superior outcomes.

Vascular disease

OHSU's vascular disease program includes nationally renowned experts specially trained to diagnose and treat the entire spectrum of arterial, venous and lymphatic disorders. A team of providers, including vascular, cardiothoracic and endovascular surgeons, treats the carotid artery and extracranial cerebrovascular system, aneurysms of the thoracic and abdominal aorta, intestinal and kidney arteries and veins, upper and lower extremity arteries and veins, patients with Raynaud's syndrome, those requiring vascular access for hemodialysis as well as patients with varicose veins, venous thrombosis, lymphedema and vascular malformations.

Women's heart

In collaboration with the OHSU Center for Women's Health, the women's heart program focuses on primary prevention to reduce risk in women without known cardiovascular disease, secondary prevention to improve the health of women diagnosed with disease, and cardio-oncology to manage heart risks in women who have undergone breast cancer treatment. By understanding the differences in how heart disease manifests in women and studying the disparities in treatment and response to medication, this program aims to provide a forum for providers to improve care and health outcomes using the most current evidence-based information.



Pushing boundaries in research

Leading discovery into the origins of cardiovascular health

Could having an average birth weight be the cure for cardiovascular disease? Research by OHSU Knight Cardiovascular Institute shows that birth weight highly influences cardiovascular development. Adults whose birth weight was between 7.5–8.5 pounds have the lowest rate of cardiovascular disease and have the most resistance to developing it regardless of lifestyle factors. Alternatively, low and high birth weights predispose people to increased risk of cardiovascular disease and other chronic diseases later in life.

“We’ve been able to show that virtually every cardiac abnormal condition is related to how someone’s heart and cardiovascular system developed before birth and in very early life — that’s when the health of the individual is determined,” said Kent L. Thornburg, Ph.D., director of the Center for Developmental Health at OHSU and interim director of the Knight Cardiovascular Institute. “Heart disease and diabetes could be reduced by half if more babies were born in the healthy birth weight range and avoid obesity before 8 years old.”

For more than 30 years, OHSU has contributed significantly to the literature in the rapidly growing field of the developmental origins of health and disease (DOHaD). Our work in this arena began in the 1990s, evolving into the Center for Developmental Health at the OHSU Knight Cardiovascular Institute in 2013.

“Our scientists have joined other global colleagues to study every aspect of DOHaD, even going back to maternal and grandmaternal diets,” Thornburg said. “We have learned how nutrition has a

profound effect on the embryo as it travels down the oviduct on its way to the womb, where it will implant and cause a pregnancy. If nutrient levels are low, the embryo will make a larger placenta. The placenta then takes a larger share of the nutrients for itself before the baby, which affects birth weight and the development of blood vessels and heart structures. Our colleagues have shown that six months of a healthy diet before pregnancy results in a bigger baby, a smaller placenta and fewer cognitive disorders in children.”

Even heart defects are largely a factor of fetal environmental stressors, with a much smaller percentage genetic in origin. Our scientists have shown that elevated sugar levels in the blood of an embryo and fetus change the heart’s structure and lead to heart defects. That heart defects are associated with maternal diabetes is well documented.

“We know that people who have heart failure at 50 had fetal environmental changes that made them vulnerable to heart disease,” Thornburg said. “These are epigenetic in origin, where the gene expression is modified and becomes detrimental to the heart and blood vessels. However, there are good data that these epigenetic effects can be reversed by a healthy diet and lifestyle changes, especially in children.”

Similarly, the research of cardiothoracic surgeon Frederick A. Tibayan, M.D., showed in a preclinical model that the impact of sustained, elevated arterial pressure load on the fetal heart leads to structural changes in the heart valves that have implications for the likelihood of developing valve disease in later life.



“What all this data tell us is that an individual’s birth history — birthweight, mother’s health during pregnancy — is as important as a family history of disease in understanding a person’s risk for acquiring heart disease.”

Kent L. Thornburg, Ph.D.,
director of the Center for
Developmental Health
at OHSU and interim
director of the Knight
Cardiovascular Institute

“What all this data tell us is that an individual’s birth history — birth weight, mother’s health during pregnancy — is as important as a family history of disease in understanding a person’s risk for acquiring heart disease,” Thornburg said.

“We predict that personalized medicine will take advantage of a person’s epigenetic profile to predict cardiovascular disease risk long before a person shows symptoms. When we have that information, we can adjust risk factors to intervene sooner.”

Four environmental stressors affecting lifelong cardiovascular health

OHSU has discovered that one or more of these stressors leads to abnormal heart and blood vessel health in a fetus. Though physicians have long known the importance of prenatal nutrition, these other social determinants and exposures are as influential in the development of cardiac disease later in life. For the first time in history, we understand the primary factors that lead to adult onset of chronic diseases.



Nutritional stress

Poor diet/food insecurity
before and during pregnancy



Social stress

Housing insecurity,
abuse, systemic racism



Toxic chemicals

Lead, plasticizers,
phthalates



Low oxygen

Caused by inadequately
developed placenta or blood supply

Driving clinical success through research

OHSU Knight Cardiovascular Institute is actively researching new methods to understand, prevent and treat cardiovascular disease for the people of Oregon and beyond. Areas of research excellence include cardiovascular imaging, cardiovascular device design, cardiac surgery and transplantation, and epigenetics.

Fresh take on comparing the effect of kinase inhibitors on platelets

OHSU researchers found that pharmacologic inhibitors of the spleen tyrosine kinase (Syk) and Bruton's tyrosine kinase (BTK) have overlapping and distinct effects on blood platelets. These results will help scientists to better understand and mitigate bleeding side effects from drugs like ibrutinib (Imbruvica), now commonly used in hematologic cancers. Increased information of the underlying mechanism of these inhibitors on platelet function and signaling may also have therapeutic utility. For instance, Syk and BTK inhibitors could serve as antiplatelet agents in inflammatory and thrombotic pathologies, including atherothrombosis and immune responses in COVID-19.

Joseph Aslan, Ph.D., senior author on the study, said the student-led team investigated the effects of 12 different Syk and BTK inhibitors on platelets.

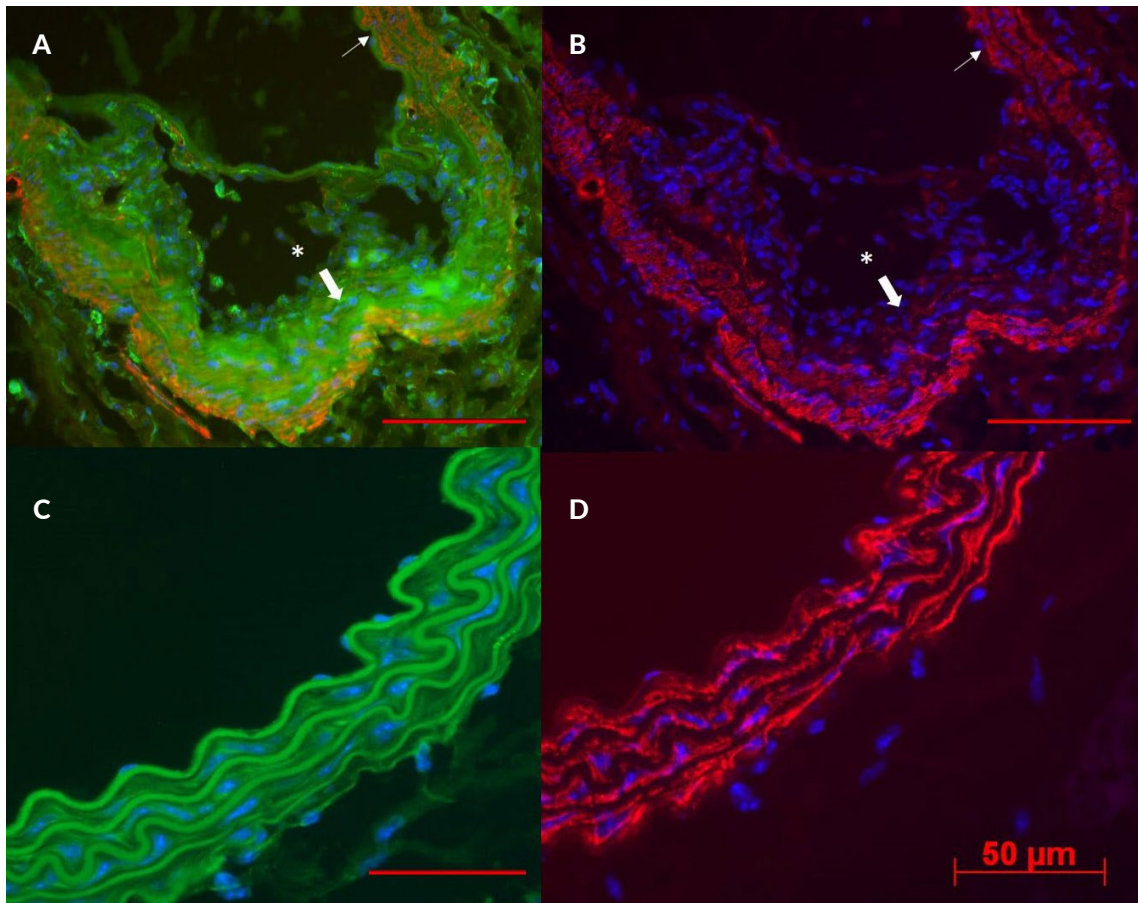
"Interestingly, we found that reversible, noncovalent BTK inhibitors had more potent effects on platelet signaling, platelet protein organization and platelet function in vitro than irreversible BTKs," he said. "As drugs targeting Syk, BTK and other kinases emerge as new targets in medicinal chemistry, studies such as ours will help to address the effects of such compounds at the molecular level in signaling in platelets and other cell types."

The paper, "Assessment of the effects of Syk and BTK inhibitors on GPVI-mediated platelet signaling and function," was led by Tony Zheng, an OHSU M.D./Ph.D. student in the OHSU Department of Biomedical Engineering and published in the *American Journal of Physiology – Cell Physiology*.

A novel model to assess tobacco smoke effects leading to abdominal aortic aneurysm

With the known link between abdominal aortic aneurysm and tobacco use, vascular surgeon Amir F. Azarbal, M.D., M.C.R., is investigating the disease process in a new way: from the beginning, rather than the end.

The existing preclinical models did not serve this purpose, because they inadequately translate to human experience. Azarbal created a new model by using solubilized tobacco smoke through an automatic pump implanted under the skin. In this way, the model receives a controlled and constant nicotine release over time, similar to how humans have a cigarette multiple times a day rather than a whole pack at once.



Area of aortic injury in a smoke-exposed model (thick arrow, A and B) demonstrating aortic injury (*) and alteration of protein expression compared to vehicle-exposed models (C and D).

Also, the smoke solution solubilizes a very broad range of tobacco smoke components in addition to nicotine. In this way, it may be more representative of human smoke exposure than models that use nicotine alone. For this study, the model has no other genetic alterations or degenerative processes initially.

Using this model, Azarbal's study started with the dose of nicotine equivalent to five to eight cigarettes a day in humans for a month. He found that the elastin begins to break down and that smooth muscle cells in the aorta expressed different markers, transforming in appearance to inflammatory cells. These changes were predominantly in the abdominal aorta.

The next steps of the study will be to increase the intensity and duration of nicotine exposure in increments, noting changes at each stage.

"We want to capture every stage of the disease process," Azarbal said. "Typically, we create an aneurysm and then work backward. By working in a forward fashion, it's going to be a slower process, but we'll be able to provide more mechanistic detail and attribute changes to the various insults."

The data gathered from this study could help determine whether there are opportunities to interrupt the disease process or even reverse these changes, translating into therapies to prevent abdominal aortic aneurysms.

Research groups



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Innovations
in Cardiovascular
Health

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Fostering collaboration and access

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Center for Health & Healing

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Portland, OR 97239
503-494-1775

Beaverton Cardiology Clinic

15700 S.W. Greystone Court
Beaverton, OR 97006
503-494-1775

Adventist Health Portland

an OHSU Health partner location

10123 S.E. Market St.
Portland, OR 97216
503-257-2500

Hillsboro Medical Center

an OHSU Health partner location

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Hillsboro, OR 97123
503-681-1111

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St. John Medical Center

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PeaceHealth

Southwest Medical Center

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360-514-4444

Columbia Memorial Hospital

2095 Exchange St., Ste. 301
Astoria, OR 97103
503-338-4087

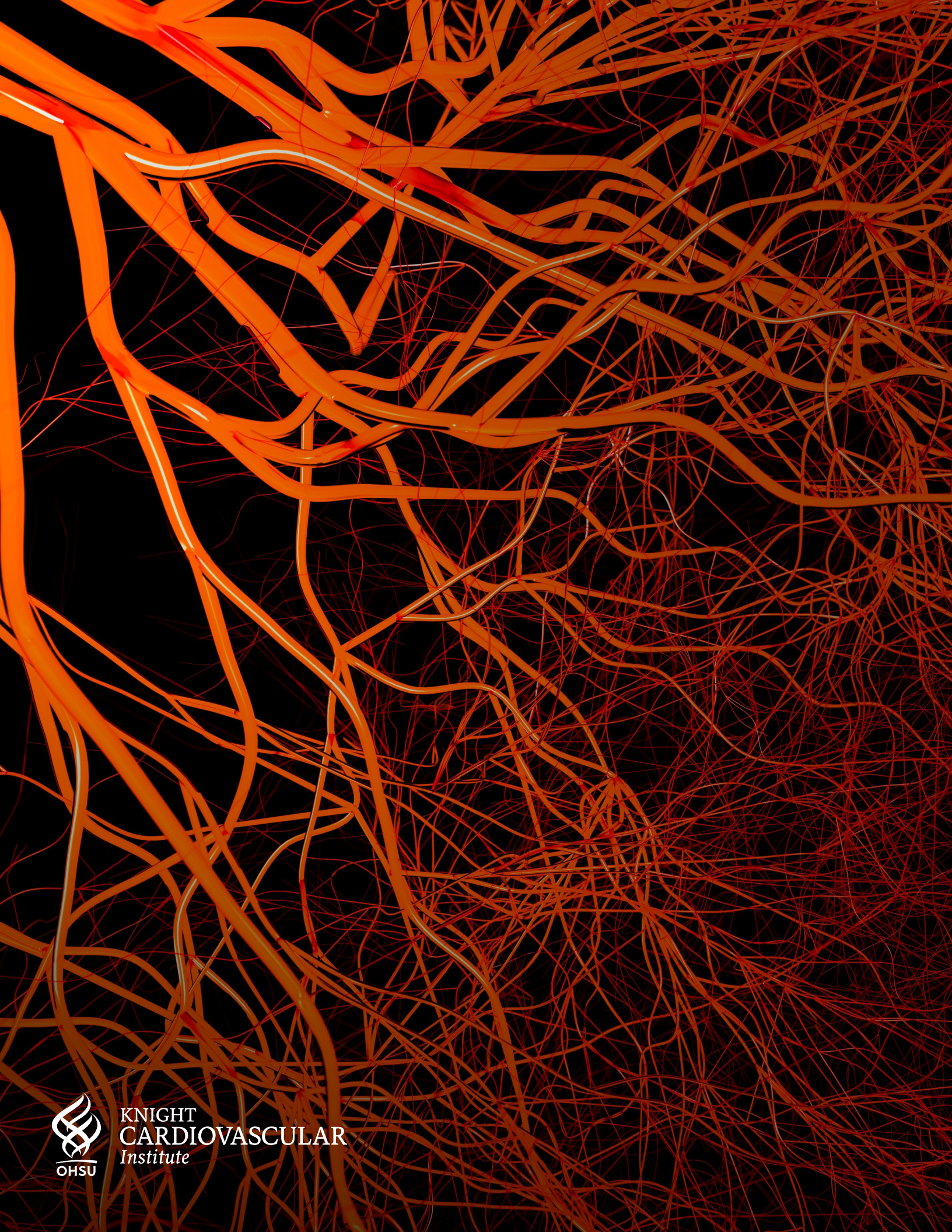
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Willamette Valley Medical Center

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