



MAYO CLINIC HEART CARE

SERVICES + INNOVATIONS + OUTCOMES

- + CARDIOLOGY
- + CARDIOVASCULAR SURGERY
- + PEDIATRIC CARDIOLOGY



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HEART CARE AT MAYO CLINIC: AN OVERVIEW

INNOVATION AND EXCELLENCE DRIVE OUR PATIENT-CENTERED PRACTICE

Our practice covers every specialty and subspecialty of cardiovascular medicine and surgery in every person—newborns to elders, men, women and children—supported by a cardiac innovation portfolio of pioneering insights and techniques adopted around the world to improve heart health and lives.

OUR MISSION

Our mission is to provide the best heart care to every patient every day through the highly focused, expert integration of clinical practice, education and research.

We do this by placing the most highly trained and experienced physician-scientists, researchers, educators and allied health professionals in creative, collaborative teams. We support their talents and commitment to patient care by equipping them with the most advanced technologies and facilities.

TRUST THE TEAM

Most of all, we trust our teams to work humanely, expertly, imaginatively and originally to create optimal solutions for patients' heart health and healing.

MOVING FORWARD WITH YOU

We apply innovation through collaboration to move advances expediently from laboratories and early-phase findings to patient care. Working with you, we do this with the help of the large volume of clinical trials we lead, participate in and manage.

On the following pages, we offer a brief overview of cardiovascular activities at Mayo Clinic.

Our intent is to update you on what we do best and what we value most.

Our hope is that these insights will help us connect with you so we can align our efforts to co-create the next generation of cardiovascular care.

CO-CREATING CHANGE

As we all know—sadly and too well—the burden of heart disease on humankind is far too large and complex for any one institution acting alone to make the difference the disease requires. Together, we can change that.

CARDIOVASCULAR CARE CHAIRS

ROCHESTER, MINNESOTA



Charanjit S. Rihal, M.D. Joseph A. Dearani, M.D. Frank Cetta, M.D.
Cardiovascular Diseases *Cardiac Surgery* *Pediatric Cardiology*

PHOENIX/SCOTTSDALE, ARIZONA



Win-Kuang Shen, M.D. Octavio E. Pajaro, M.D., Ph.D.
Cardiovascular Diseases *Cardiovascular and Thoracic Surgery*

JACKSONVILLE, FLORIDA



Kevin P. Landolfo, M.D. Leslie T. Cooper Jr., M.D.
Cardiovascular Surgery *Cardiovascular Diseases*

WHY MAYO CLINIC?

SAFETY | Critical Vigilance

Our culture of safety sets the tone for all we do in our Mayo Clinic heart practice. We are always analyzing and critically scrutinizing outcomes as we look for ways to continually improve patients' experiences and lives.

INTEGRATION | Collaborate, Communicate

As the first, oldest and largest integrated, not-for-profit medical group practice in the world, Mayo Clinic has a tradition of collaborating across medical, surgical and innovation fields to solve patients' problems. In the 1880s, the Mayo brothers invited collaborators with complementary skills to work and investigate with them—a time when solo practice was the reigning medical model. The Mayo brothers believed otherwise. They embraced the power of the group to spark new insights that improve outcomes, and to communicate results. We still do. In 2014, more than 700 articles were published by Mayo Clinic heart specialists, many of them reporting results of collaborative studies conducted nationally and internationally.

INNOVATION | Imagination Serves Well-being

Mayo Clinic physician scientists are creative engines of discoveries in heart health. In 2014 alone, Mayo Clinic teams filed a total of 43 patents across its three main campuses. Original vision like this, combined with Mayo's translational expertise to rigorously test concepts in clinical trials, creates partnership opportunities for you to help move heart health radically forward. In 2014, Mayo heart teams led or participated in 677 clinical trials based in Minnesota and 25 in Arizona. To further facilitate translational research, we have approximately 6 million patient histories and more than a century's worth of annotated blood and tissue specimens—both healthy and diseased samples—curated from circa 1910 to present. Next-generation therapies under investigation include stem cell repairs, new models of less-invasive surgeries, novel methods for faster recoveries, more successful heart disease prevention programs, and understanding the biology of sex/gender effects on heart health to further individualize care.

EXPERTISE | Right Diagnosis = Right Treatment

We prioritize ongoing advanced training to master the latest techniques and technologies needed to offer the best care to an increasingly complex and heterogeneous patient population. As a result, we develop true and deep expertise in the evaluation and management of all cardiovascular conditions. This expertise is the foundation of our clinical excellence: Right diagnosis = right treatment.

VALUE | Mastery + Efficiency

Since its founding more than 150 years ago, Mayo Clinic has followed a whole-system integrated specialties model to create efficiency and value. In addition to interdisciplinary teams of physicians and scientists, this model applies to areas not intimately involved in patient care. Administrators, finance, insurance and legal experts manage non-medical concerns so physicians and scientists are free to focus exclusively on Mayo's health mission question: What is best for the patient? Freedom to focus creates value through efficient use of mastery and expertise.

Focus on **HEART DISEASE IN WOMEN**

In 1938, Mayo Clinic's Fredrick Willius, M.D., became one of the first cardiologists to recognize sex and gender differences in heart disease. Passionate about the prevention of heart disease, Dr. Willius was a pioneer in recognizing the role of diet, lifestyle and hypertension in coronary artery disease process. He played a pivotal role in the formation of the American Heart Association and was one of the founders of the Minnesota Heart Association.



In a landmark publication in 1940, Dr. Willius was the first to demonstrate a large-sample statistical association of smoking and coronary artery disease in an analysis of 2,000 male subjects. His work in preventive cardiology continues today at Mayo Clinic, particularly in the Cardiovascular Health Clinic and Women's Health Clinic.

Mayo fellow Dr. LaPrincess Brewer (right), has studied the attitude of African American women towards clinical research. Dr. Rekha Mankad (left), is a specialist in rheumatoid arthritis and the heart. Also pictured (center) is cardiology fellow Dr. Sonia Jain.

OUR LEADERSHIP LEGACY: A SNAPSHOT

Scores of Mayo Clinic heart specialists have garnered awards for distinction in their fields, and many have been honored to serve leadership positions of national professional societies. We offer but a sampling below.

In 2014, Bernard J. Gersh, M.B., Ch.B., D.Phil., David R. Holmes Jr. M.D. and Veronique L. Roger, M.D., cardiologists at Mayo Clinic in Rochester, were included on the list of “The World’s Most Influential Scientific Minds,” published by Thomson Reuters

American Association of Cardiovascular and Pulmonary Rehabilitation

2009-2010 Randal J. Thomas, M.D., President

American Association for Thoracic Surgery

2012-2013 Hartzell V. Schaff, M.D., President

1994-1995 Robert B. Wallace, M.D., President

1983-1984 Dwight C. McGoon, M.D., President

1978-1979 John W. Kirklin, M.D., President

1961-1962 O. Theron Clagett, M.D., President

1937-1938 Stuart W. Harrington, M.D., President

1921-1922 Samuel Robinson, M.D., President

American College of Cardiology

2011-2012 David R. Holmes Jr., M.D., President

2002-2003 W. Bruce Fye, M.D., M.A., President

1991-1992 Robert L. Frye, M.D., President

1980-1981 Robert O. Brandenburg, M.D., President

American Heart Association

2006-2007 Raymond J. Gibbons, M.D., President

1998-1999 Valentin Fuster, M.D., Ph.D., President

1976-1977 John T. Shepherd, M.D., President

1967-1968 Jesse E. Edwards, M.D., President

1956-1957 Edgar V. N. Allen, M.D., President

1947-1948 Arlie R. Barnes, M.D., President

American Society for Clinical Pharmacology and Therapeutics

2004-2005 Andre Terzic, M.D., Ph.D., President

American Society of Echocardiography

2011-2012 Patricia A. Pellikka, M.D., President

2005-2006 Bijoy K. Khandheria, M.D., President

American Society for Preventive Cardiology

2012-2014 Stephen L. Kopecky, M.D., President

Heart Rhythm Society

2010-2011 Douglas L. Packer, M.D., President

2004-2005 Stephen C. Hammill, M.D., President

1998-1999 David L. Hayes, M.D., President

Pediatric & Congenital Electrophysiology Society

2015-2018 Bryan C. Cannon, M.D., Vice President

Pulmonary Hypertension Association

2006-2008 Michael D. McGoon, M.D., Chair, Board of Trustees

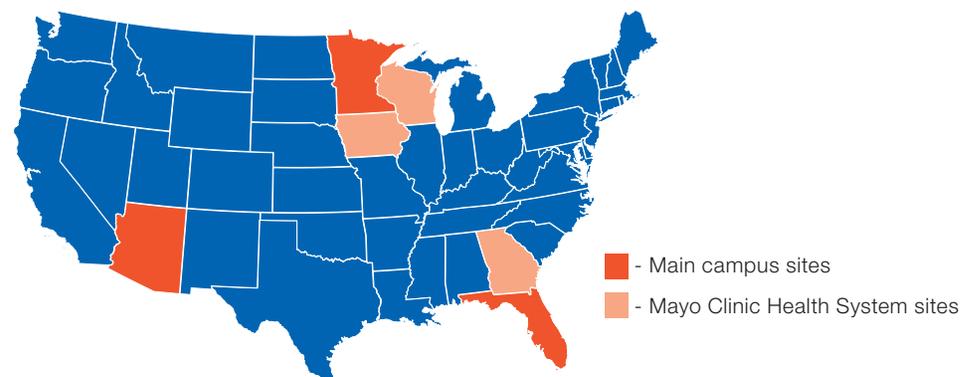
Society for Cardiovascular Angiography and Interventions

1995-1996 David R. Holmes Jr., M.D., President

LOCATIONS: MAYO CLINIC’S U.S. SERVICE AREAS

Our three main campuses are in Rochester, Minnesota; Phoenix/Scottsdale, Arizona; Jacksonville, Florida. We also serve people in more than 60 U.S. communities across Iowa, Georgia, Minnesota and Wisconsin through the Mayo Clinic Health System, a network of clinics, hospitals and health care facilities providing primary and specialty care.

International patients are served at each main campus. With the help of translators and interpreters fluent in all major world languages and health navigators specializing in cultural competencies, international visitors and their families easily and comfortably get the help they need organizing and completing a visit. To ease appointment scheduling and arrange follow-up and support care at home, Mayo Clinic maintains offices in Canada, Colombia, Ecuador, Guatemala and Mexico.



PHOENIX/SCOTTSDALE, ARIZONA

Our team of cardiac and thoracic surgeons provides comprehensive care that is well integrated with our Mayo colleagues in Minnesota and Florida. We collaborate with EXOS training company to provide specialty care for professional athletes, and are an active enrollment site for national research trials.

Cardiovascular Surgery

Multidisciplinary care teams perform more than 800 cardiothoracic surgeries each year in adults, including lung transplantation; total artificial heart placement; ventricular remodeling procedures; left ventricular assist device (LVAD) placement and evaluation for transplantation; heart valve surgeries for aortic, mitral, pulmonary, and tricuspid valve repair and replacement; and transcatheter aortic valve replacement (TAVR).



- + Heart Transplant and Mechanical Circulatory Support (Surgical and Medical Clinics)



- + Adult Congenital Heart Disease Clinic
- + Advanced Heart Failure and Pulmonary Hypertension Clinic
- + Arrhythmia Surgery Clinic
- + Cardiac Rehabilitation Clinic
- + Cardiovascular Oncology Clinic
- + Clinical Cardiology Clinic
- + Heart Health and Performance Clinic
- + Heart Rhythm Services Clinic
- + Hypertrophic Cardiomyopathy Clinic
- + Ischemic Heart Disease Clinic
- + Pericardial Disease Clinic
- + Structural Heart Disease Clinic
- + Valvular Heart Disease Clinic

Cardiovascular Disease Expertise and Assets

Offerings include:

- + **Expert management of advanced heart failure** and pulmonary hypertension, leading Arizona health care providers in heart transplantation and LVAD placement and specializing in minimally invasive valve repair for adult congenital heart disease



- + Echocardiography Laboratory
- + Interventional Cardiology Laboratory
- + Nuclear Cardiology Laboratory
- + Translational Ultrasound Research Laboratory
- + Vascular Disease (Medical and Surgical Laboratories)

- + **Cardiac rehabilitation** and cardiovascular oncology services
- + **Heart rhythm services** specializing in hypertrophic cardiomyopathy evaluation, management and surgery (septal myectomy); pericardial disease; valvular disease

Cardiovascular Laboratories Assets

- + **Electrophysiology Laboratory** specialists perform complex adult ablations, radiofrequency and cryoablation for supraventricular arrhythmias (for example, AV node re-entry, WPW, atrial flutter, atrial fibrillation) and ventricular tachycardia and cardiogenic syncope; repeat procedures for patients whose previous ablations have failed.
- + **Echocardiography Laboratory** specialists perform more than 20,000 procedures annually.
- + **Interventional Cardiology Laboratory** specialists perform more than 2,500 procedures annually, specializing in complex coronary interventions, peripheral vascular interventions, pericardiocentesis and structural heart interventions (TAVR, ASD/PFO closure). We offer enrollments in national research stem cell therapy trials, and provide percutaneous support devices for patients with cardiogenic shock and advanced heart failure.
- + **Nuclear Cardiology** specialists focus on the use of noninvasive techniques such as myocardial perfusion imaging.
- + **Translational Ultrasound Research Laboratory** aids the diagnosis and treatment of vascular disease.



JACKSONVILLE, FLORIDA

Mayo Clinic, Jacksonville, Florida, offers advanced cardiovascular medical, surgical and interventional services from expert teams well integrated with Mayo Clinic facilities in Rochester, Minnesota, and Phoenix/Scottsdale, Arizona.

Cardiology Expertise and Assets

Our multidisciplinary specialists are supported by advanced cardiac imaging and offer comprehensive care for adult congenital heart disease and Marfan syndrome myocarditis; complete cardiopulmonary rehabilitation services; a Cardiovascular Clinic for full-continuum heart care; expertise in assessing chest pain and coronary physiology, managing heart failure, heart rhythm disorders, hypertrophic cardiomyopathy, pulmonary hypertension, sports cardiology issues, valvular heart disease, vascular medicine and women's cardiovascular health.

Cardiovascular Laboratories Assets

- + **Electrophysiology Laboratory** specialists offer the full spectrum of patient-centered electrophysiology services for ablation of complex atrial arrhythmia, including patients who need repeat procedures for previously failed ablations; complex pacemaker and ICD lead extractions.
- + **Interventional Cardiology Laboratory** specialists offer the most advanced interventional approaches. These include advanced hemodynamic assessment with exercise for assessment of heart failure with preserved ejection fraction, constriction and restriction; minimally invasive closures of patent foramen ovale (PFO).



- + Heart Transplant and Mechanical Circulatory Support Clinic

Interventional Cardiology Expertise

Our teams specialize in TAVR; HCM septal ablations; PFO closure; paravalvular leak closure; peripheral vascular disease.

Cardiothoracic Surgery Expertise

Our division provides expertise in multiple areas of cardiothoracic surgery. Advanced care for ischemic heart disease includes on and off pump coronary bypass grafting as well as minimally invasive coronary revascularization (MIDCAB). For valvular disease, we provide minimally invasive valve repair and replacement and transcatheter aortic valve replacement (TAVR). Complex aortic disease is performed using a hybrid (surgical and endovascular) approach. Complex heart failure



- + Adult Congenital Heart Disease and Marfan Syndrome Clinic
- + Cardiopulmonary Rehabilitation Clinic
- + Circulatory Failure Clinic
- + Heart Rhythm Services
- + Hypertrophic Cardiomyopathy Clinic
- + Pulmonary Hypertension Cardiology Clinic
- + Sports Cardiology Clinic
- + Valvular Heart Disease Clinic
- + Vascular Medicine Clinic
- + Women's Heart Disease Clinic



- + Cardiovascular Imaging (CT, MRI, Nuclear Cardiology)
- + Echocardiography Laboratory
- + Interventional Cardiology Laboratory

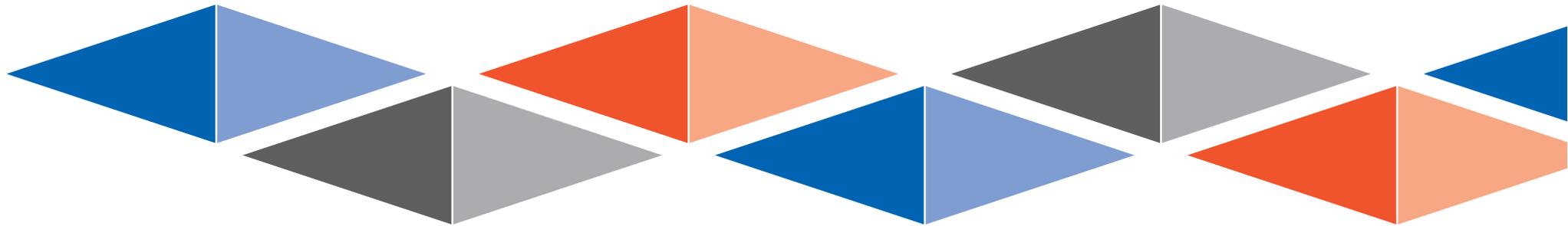


conditions treated with a surgical approach include HOCM (extended myectomy), CTEPH (pulmonary thromboendarterectomy), and end-stage heart failure requiring mechanical circulatory support (LVAD, BIVAD, ECMO). Thoracic transplantation including heart, lung, heart-lung, and multi-organ procedures in addition to novel approaches to organ preservation (EVLP) are performed.

Cardiology services are also offered at Mayo Clinic Health System in Waycross, Georgia. (formerly Satilla Health Services).

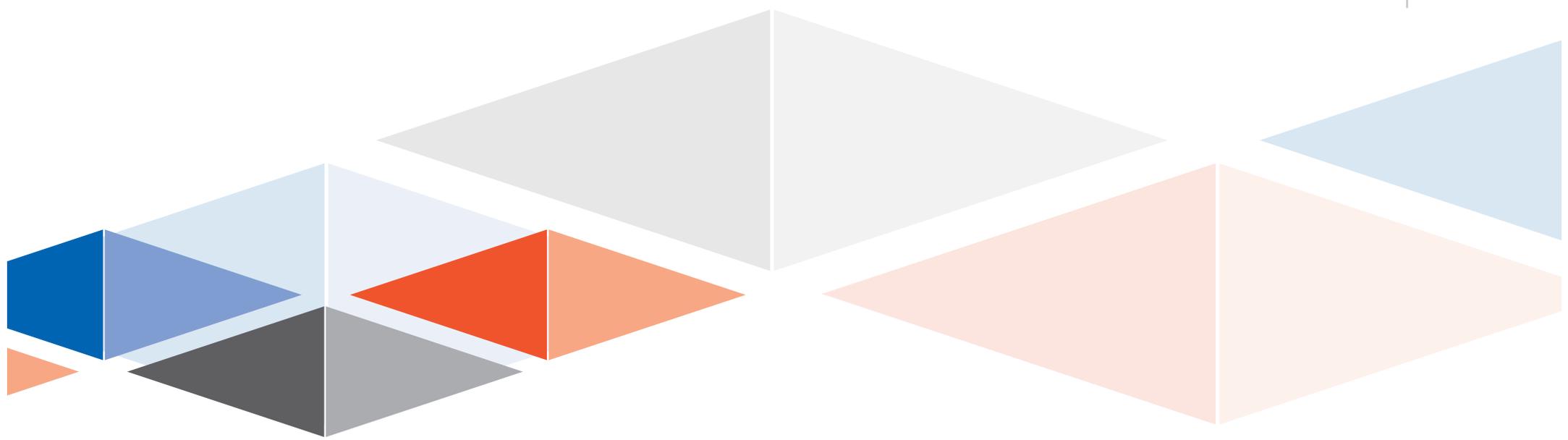
MAYO CLINIC HEART CARE

CARDIOLOGY + CARDIOVASCULAR SURGERY + PEDIATRIC CARDIOLOGY



MEDICAL + SURGICAL PROGRAMS

CIRCULATORY FAILURE PROGRAM	CARDIOVASCULAR SURGERY	COMMUNITY AND COMPREHENSIVE CARDIOLOGY	HEART RHYTHM SERVICES	ISCHEMIC HEART DISEASE PROGRAM	PEDIATRIC CARDIOLOGY PROGRAM
<ul style="list-style-type: none"> + Cardiac Amyloidosis Clinic + Heart Failure Clinic and Inpatient Services + Heart Transplant: Clinic and Inpatient Service + Left Ventricular Assist Device (LVAD): Clinic and Inpatient Service + Pulmonary Hypertension Clinic + Unexplained Dyspnea Clinic 	<ul style="list-style-type: none"> + Left Ventricular Assist Device (LVAD) Clinic + Mechanical Circulatory Support Clinic + Robotic Heart Surgery + Transcatheter Aortic Valve Replacement (TAVR) Clinic + Transplant Clinic 	<ul style="list-style-type: none"> + Community Empowerment and Networking + Consultative CV Services Through Mayo Clinic Health System + International Cardiology Services + Ongoing Research into Science of Health Care Delivery 	<ul style="list-style-type: none"> + Electrophysiology Laboratory + Heart Rhythm Clinic and Inpatient Services + Heart Rhythm and Physiological Monitoring Laboratory + Implantable Device Laboratory + Long QT Syndrome/Genetic Heart Disorders Clinic 	<ul style="list-style-type: none"> + Chest Pain and Coronary Physiology Clinic + Coronary Artery Disease Clinic and Inpatient Services + Earl H. Wood Cardiac Catheterization Laboratory 	<ul style="list-style-type: none"> + Arrhythmia Disorders + Congenital Heart Care + Echocardiography Specialty Service in Congenital Heart Disorders + Pediatric Cardiovascular Surgery Clinic



PREVENTIVE CARDIOLOGY PROGRAM

LABORATORIES FOR CV DIAGNOSIS, THERAPY, RESEARCH

PREVENTIVE CARDIOLOGY PROGRAM

- + Comprehensive Inpatient Services
- + Cardiac Rehabilitation Clinic
- + Cardio-Oncology Clinic
- + Cardio-Rheumatology Clinic
- + Cardiovascular Health Clinic
- + Early Atherosclerosis Clinic
- + Sports Cardiology Clinic
- + Statin Intolerance Service
- + Stress Laboratory
- + Women's Heart Clinic

STRUCTURAL HEART DISEASE PROGRAM

- + Congenital Heart Disease Clinic
- + Heart Brain Clinic
- + Hypertrophic Cardiomyopathy Clinic
- + Marfan Syndrome and Thoracic Aortic Aneurysm Clinic
- + Pericardial Disease Clinic
- + Valvular Heart Disease Clinic

VASCULAR MEDICINE PROGRAM

- + Outpatient Vascular Consult
- + Thrombophilia Clinic
- + Vascular Surgery and Interventional Radiology
- + Vascular Wound Care Clinic
- + Vasculitis Clinic
- + Vein Clinic

- + Cardiovascular Biomarkers Laboratory
- + Cardiovascular Contractility and Signaling Laboratory
- + Cardiovascular Disease and Aging Laboratory
- + Cardiovascular Epidemiology and Outcomes Laboratory
- + Cardiovascular Genetics Laboratory
- + Cardiovascular Imaging Laboratory
- + Cardiovascular Molecular Imaging Laboratory
- + Cardiovascular Research Center
- + CT Laboratory
- + CV Innovation Laboratory
- + Echocardiography Laboratory
- + Interventional Cardiology Laboratory
- + MRI Laboratory
- + Nuclear Cardiology Laboratory
- + Todd and Karen Wanek Family Program for Hypoplastic Left Heart Syndrome
- + Ultrasound Research Laboratory
- + Windland Smith Rice Sudden Death Genomics Laboratory



MAYO CLINIC BY THE NUMBERS 2014

In 2014:

1.3 million people from all 50 states and
143 countries came to Mayo Clinic for care.

STAFF

Physicians and scientists 4,200
Administrative and allied health staff..... 52,900

PATIENTS

Annual unique patients..... 1,317,900
Annual hospital admissions..... 128,000
Annual hospital days of patient care..... 612,000

RESEARCH

Total annual research budget\$648 million
Centers & programs 46
Core Laboratories..... 29
Research laboratory space 347,926 square feet
Active grants and contracts..... 4,110
Active Institutional Review Board-approved
human research studies..... 9,832
Annual research and review articles in
peer-reviewed journals 6,392

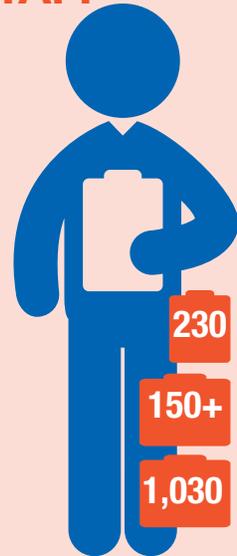
EDUCATION

Residents and fellows1,665
Graduate students 331
Medical students216
Health sciences students 1,843
CME participants..... 127,616

MAYO CLINIC HEART CARE BY THE NUMBERS

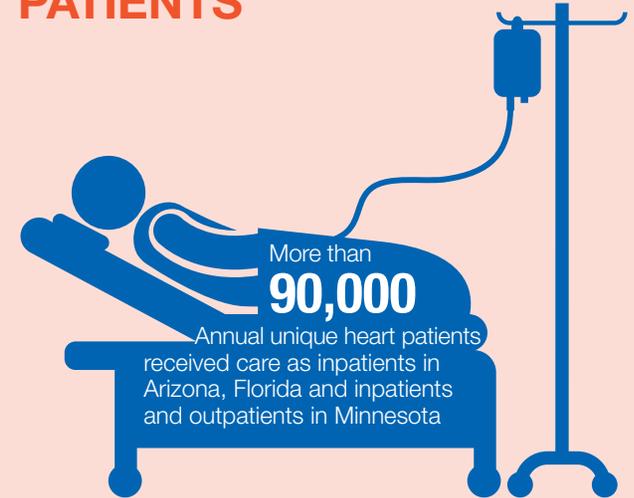
AGGREGATE FOR THREE SITES, 2014

STAFF



230 CV specialists
150+ Clinicians and scientists
involved in research
1,030 Administrative and
allied health staff

PATIENTS



More than
90,000
Annual unique heart patients
received care as inpatients in
Arizona, Florida and inpatients
and outpatients in Minnesota
>11,500 Annual hospital heart
admissions

RESEARCH

Mayo Clinic Cardiovascular Disease Inventions and Discovery

In Arizona, Florida and Minnesota between
2010 and 2014, there were:

161 DISCLOSURES

45 TECHNOLOGIES LICENSED OR OPTIONED

95 PATENTS ISSUED **220** PATENTS FILED

EDUCATION

Training in CV Diseases

97% Pass rate for CV Boards
between 2010-2014

CV Fellows' Publication Rate

>60 Novel research findings published in a typical
year such as 2014

Continuous Professional Development

4.65 out of 5.0 scale
overall CME satisfaction rating

\$15.5 million

GROSS ROYALTIES RECEIVED (rounded)

SELECTED PROCEDURAL VOLUMES BY PROGRAM AND LABORATORY

DATA FROM 2014, ENTERPRISE-WIDE, EXCEPT AS NOTED



CIRCULATORY FAILURE PROGRAM
HEART TRANSPLANT CLINIC **89** Annual cardiac transplants



HEART RHYTHM SERVICES
ELECTRO-PHYSIOLOGY LABORATORY*** **1,582** Radiofrequency/image-guided ablation of complex ventricular arrhythmias
>750 Pulmonary vein isolations performed for atrial fibrillation
796 ICD implants/removals
1,169 Pacemaker implants/removals
279 Biventricular pacemaker implants
279 Biventricular ICD implants

HEART FAILURE CLINIC* **6,266** Outpatients treated



ISCHEMIC HEART DISEASE PROGRAM
CARDIAC CATHETERIZATION LABORATORY **48** High-risk (LVAD-supported) PCI (Impella and Tandem Heart)
7,388 Diagnostic catheterizations
743 Coronary physiology studies (IVUS)
56 Balloon valvuloplasty procedures
1,791 Percutaneous Interventions (PCI)
234 Percutaneous valve procedures (Perc femoral TAVR, Melody, TMVR)

CORONARY ARTERY DISEASE CLINIC*** **1,147** Coronary artery bypass graft (CABG) surgeries



PREVENTIVE CARDIOLOGY PROGRAM
PREVENTIVE PROGRAM* **15,388** Comprehensive Cardiology
7,984 CV Health Clinic
1,743 CV Women's Heart Clinic



STRUCTURAL HEART DISEASE PROGRAM
CONGENITAL HEART DISEASE **775** Congenital heart surgeries
ECHO-CARDIOGRAPHY LABORATORY **78,828** Adult TTE
7,661 Congenital TTE and TEE combined
2,499 Adult Intraoperative TEE
5,844 Adult TEE
139 Pericardiocentesis
203 Fetal Echocardiograms
15,840 Stress Echocardiograms
696 Research Echocardiograms
1,109 Miscellaneous
112,819 Total combined volume

HYPERTROPHIC CARDIOMYOPATHY CLINIC **238** Myectomy/myotomy procedures

MARFAN SYNDROME AND THORACIC AORTIC ANEURYSM **293** Thoracic aortic aneurysm or dissection repairs

PERICARDIAL DISEASE CLINIC **73** Pericardiectomies performed for patients whose disease required surgical management



VASCULAR MEDICINE PROGRAM
THROMBOPHILIA CLINIC* **>4,000** Outpatient visits annually
VASCULAR MEDICINE PROGRAM* **13** Fully trained vascular specialists to support a rotating schedule so that two evaluate and treat the 10-14 new patients each day
>3,300 Unique patient visits, nearly equally divided between arterial and venous disorders, require vascular medicine consultation each year
10% Approximate percentage of referred patients with lymphatic disease

VASCULAR SURGERY AND INTERVENTIONAL RADIOLOGY* **1,800** Procedures
4,600 Outpatient visits

VASCULAR ULTRASOUND LABORATORY* **10** Examination rooms fully equipped with state-of-the-art Acuson Sequoia ultrasound machines
17,000 Procedures performed each year
10 Vascular radiologists extensively trained in vascular ultrasound (RVT certified)
40 Sonographers extensively trained in vascular ultrasound (RVT certified)

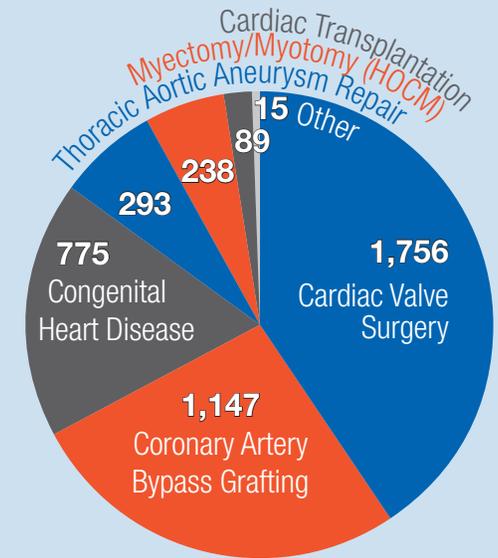
VASCULAR WOUND CARE CLINIC* **>3,500** Outpatient visits annually
88% Healing success rate
18 weeks: Average time to heal a wound

VEIN CLINIC* **>5,000** Studies performed each year in eight examination rooms
>5,000 Studies performed each year in the Noninvasive Peripheral Vascular Laboratory



in Rochester, Phoenix/Scottsdale and Jacksonville combined, there were:

4,313 Total Surgical Patients



* = Rochester only

*** = Three sites only: Arizona, Florida, and Minnesota

Enterprise-wide heart data include values from Mayo Clinic's three main campuses in Arizona, Florida and Minnesota and the 30 members of the Mayo Clinic Health System that provide specialized heart care.

1 CIRCULATORY FAILURE PROGRAM

SUBSPECIALTIES

- † Cardiac Amyloidosis Clinic
- † Heart Transplant Clinic and Inpatient Service
- † Heart Failure Clinic and Inpatient Service
- † Left Ventricular Assist Device (LVAD) Clinic and Inpatient Service
- † Pulmonary Hypertension Clinic
- † Unexplained Dyspnea Clinic

CIRCULATORY FAILURE PROGRAM

Mayo Clinic's Division of Cardiovascular Diseases has six specialized clinics, many with associated inpatient services that care for patients with life-threatening or debilitating failure of the circulatory system. In 2014, at our Rochester, Minnesota, facility alone, we treated more than 6,200 outpatients with circulatory failure.

CARDIAC AMYLOIDOSIS CLINIC

Teams of specialists evaluate patients with all types of proven or suspected cardiac amyloidosis, most commonly AL, wild-type TTR (senile systemic amyloidosis) or familial TTR amyloidosis.

Expertise in evaluation and care of all forms of amyloidosis

- + Light chain (AL), familial transthyretin (TTR), wild type (“senile”) TTR and rarer forms of amyloidosis with cardiac involvement
- + Collaboration with the Division of Hematology’s Dysproteinemia Clinic, an internationally recognized leading center for the care of patients with monoclonal gammopathies, amyloidosis and multiple myeloma
- + Collaboration with nephrologists, neurologists, radiologists, transplant cardiologists and cardiac surgeons

Diagnostic advances and techniques

- + First in the country to provide laser microdissection and mass spectrometry to identify the specific type of amyloid in biopsy specimens
- + Worldwide reference lab for amyloid typing
- + Imaging expertise in helping define the echocardiographic and MRI features of cardiac amyloidosis
- + One of few centers offering pyrophosphate (PYP) SPECT scanning for detection of TTR cardiac amyloid
- + Pioneer in developing a novel PET scan for detection of cardiac and potentially total body burden of amyloidosis

Comprehensive spectrum of therapies

- + Chemotherapies
- + Selected use of autologous stem cell transplant
- + Novel treatments: heart transplant, LVAD and total artificial heart
- + Leading center for liver transplant and combined heart-liver transplant for familial (TTR) amyloidosis

Selected Mayo Clinic research highlights

- + Development of the major prognostic algorithm linking cardiac biomarkers and other factors to patient outcomes
- + High-impact studies of cardiac amyloidosis reports published in *New England Journal of Medicine*, *Circulation* and *Journal of the American College of Cardiology*
- + Clinical trials for AL and TTR cardiac amyloidosis in progress

HEART TRANSPLANT CLINIC AND INPATIENT SERVICE

All Mayo Clinic specialists in this field are certified by the American Board of Internal Medicine Advanced Heart Failure and Transplantation Cardiology and continue the Mayo leadership legacy in the field.

Expertise in single- and combined-organ transplant, evaluation and care of both children and adults

- + Survival rates exceed national average (2009-2011 Mayo Clinic one-year survival: 95.8 percent; national average, 90.2 percent)
- + Large volume of heart-combined organ procedures
- + More than 1,000 heart transplants since 1988, with 89 in 2014)

Comprehensive spectrum of therapies

- + Heart-lung transplants
- + Heart-kidney transplants
- + Heart-liver transplants
- + Heart-liver-kidney transplants
- + Often able to perform transplants in patients considered inoperable elsewhere due to complexity and high risk, such as cases involving rare causes of heart failure, including cardiac amyloidosis and patients with challenging comorbidities

Selected Mayo Clinic research highlights

- + 96 heart and multiorgan transplant publications in peer-reviewed journals.
- + Defined novel immunosuppression regimens for patients undergoing cardiac transplant.
- + Investigating the mechanisms of post-transplant cardiac allograft vasculopathy (CAV).
- + In 1955, among the first to perform successful open-heart surgery to repair congenital heart abnormalities after refining the Gibbon heart-lung bypass machine, thereafter known as the Mayo-Gibbon heart-lung bypass machine.
- + In 1996, first to perform a heart-lung-liver transplant in the U.S.

HEART FAILURE CLINIC AND INPATIENT SERVICE

To address each patient's unique needs, specialists who have American Board of Internal Medicine Advanced Heart Failure and Transplantation Cardiology certification collaborate closely in multidisciplinary teams with interventional cardiologists, electrophysiologists, exercise physiologists, nephrologists, radiologists, transplant cardiologists, cardiac surgeons, genetic counselors, and other subspecialty physicians and scientists.

Expertise in evaluation and care of all forms of heart failure

- + With reduced ejection fraction (HFrEF or "systolic heart failure")
- + With preserved ejection fraction (HFpEF or "diastolic heart failure")
- + Acute decompensated
- + Rare forms such as myocarditis, peripartum, radiation-induced, genetic and restrictive cardiomyopathies, and constrictive pericarditis
- + End-stage heart failure with the potential for responding to advanced therapies

Diagnostic techniques

- + Invasive hemodynamics, including exercise hemodynamics for assessment of HFpEF, restrictive cardiomyopathy, constrictive pericarditis and complex valvular disease in heart failure
- + Genetic testing and counseling
- + Diagnostic imaging and cardiometabolic testing

Comprehensive spectrum of therapies

- + All medical therapies
- + Cardiac surgery in patients with high-risk heart failure

- + Percutaneous coronary interventions in patients with high-risk heart failure
- + Percutaneous valve interventions in patients with high-risk heart failure
- + Heart transplantation, with 89 performed throughout the enterprise in 2014
- + Left ventricular assist device (LVAD) as bridge-to-transplant or destination therapy
- + Total artificial heart as bridge to transplant
- + Cardiac resynchronization therapy
- + Multicenter clinical trials testing novel medical and device therapies for acute and chronic heart failure

Selected Mayo Clinic research highlights

- + Investigations ongoing into gene, cell and regenerative therapies, novel pharmacological approaches, and unique device therapies for heart failure
- + Seminal high-citation scholarly contributions such as "Trends in prevalence and outcome of heart failure with preserved ejection fraction," *New England Journal of Medicine*, 2006, cited more than 1,200 times, is one example of impactful scholarly contributions from Mayo heart failure specialists.
- + Defined the epidemiology, pathophysiology, diagnostic features and novel therapy of HFpEF in more than 100 publications, including *New England Journal of Medicine*, *Journal of the American Medical Association*, *Circulation* and *Journal of the American College of Cardiology*.
- + Defined the epidemiology of HFrEF and asymptomatic ventricular dysfunction in publications such as *Journal of the American Medical Association*, *Circulation* and *Journal of the American College of Cardiology*.
- + Defined the biology, diagnostic utility and therapeutic potential of the natriuretic peptides in heart failure in more than 300 publications, including *Science*, *Journal of Clinical Investigation*, *New England Journal of Medicine*, *Journal of the American Medical Association*, *Circulation*, *Journal of the American College of Cardiology* and *American Journal of Physiology*.
- + Defined the echocardiographic assessment of diastolic function in 1997.
- + Discovery of cardiopoietic cells now being tested as a therapy for chronic advanced symptomatic heart failure in an FDA-approved, phase 3, multisite U.S. clinical trial.
- + Member of NIH-funded network of stem cell studies in cardiovascular diseases.

LEFT VENTRICULAR ASSIST DEVICE (LVAD) CLINIC AND INPATIENT SERVICE

Our team excels at assessing and evaluating patients for mechanical circulatory support, either as a bridge to transplantation or as destination therapy, with comprehensive follow-up care.

Expertise in evaluation and care of all potential LVAD patients

- + Collaborative teams of heart failure and transplant cardiologists, heart failure cardiac surgeons, cardiac anesthesiologists, social work and palliative care specialists, infectious disease specialists, and pulmonologists work together throughout the continuum of care starting with patient selection and progressing through daily management, postoperative recovery and rehabilitation.
- + Specialization for high-risk patients and novel indications, including cardiac amyloidosis and restrictive cardiomyopathies.

- + More than 300 continuous-flow LVADs implanted since 2007—awaiting update.
- + Active total artificial heart program providing bridge to heart transplant for patients in whom an LVAD provides inadequate support.

Selected Mayo Clinic research highlights

- + Participation in major mechanical circulatory support trials
- + Published approximately 140 articles pertaining to ventricular assist devices

PULMONARY HYPERTENSION CLINIC

Our team includes specialists in pulmonary hypertension, hepatologists, congenital heart defect cardiologists, rheumatologists, radiologists, exercise physiologists, pharmacists, cardiovascular surgeons and interventional cardiologists.

Expertise in evaluation and care of all forms of pulmonary hypertension

- + Internationally recognized referral center for portopulmonary hypertension

Diagnostic techniques

- + Invasive hemodynamics for assessment of complex etiologies for pulmonary hypertension
- + Combined right heart catheterization, hepatic vein wedge pressure and liver biopsy for patients with suspected portopulmonary hypertension
- + Novel comprehensive protocols for hemodynamics and right heart assessment using echocardiographic 2-D, Doppler, tissue Doppler and strain imaging; cardiac MRI; and pulmonary angiography
- + Optical coherence tomography (OCT)

Comprehensive spectrum of therapies

- + Oral, inhaled, subcutaneous and intravenous infusion of pulmonary vasoactive therapies
- + Implantable pump for chronic intravenous pulmonary hypertension therapy
- + Atrial septostomy
- + Lung transplant
- + Heart-lung transplant
- + Pulmonary thromboendarterectomy
- + Tailored pulmonary hypertension and immunosuppressive therapies for pulmonary hypertension associated with connective tissue diseases and congenital heart defects
- + Tailored pulmonary hypertension therapy and liver transplantation for patients with portopulmonary hypertension

Selected Mayo Clinic research highlights

- + Leadership in REVEAL Registry, a multicenter, observational, U.S.-based registry designed to study the longitudinal (2006 to 2013) clinical course and disease management of patients with pulmonary arterial hypertension (PAH). The REVEAL risk score is important for optimization of therapeutic strategies.
- + “Effect of phosphodiesterase-5 inhibition on exercise capacity and clinical status in heart failure with preserved ejection fraction,” *Journal of the American Medical Association*, 2013. Mayo pulmonary specialists established HFpEF as a common cause of group II pulmonary hypertension and led a clinical trial (RELAX Trial) of sildenafil for HFpEF.
- + Published ~100 articles and book chapters on pulmonary hypertension in leading journals such as *Circulation*, *Journal of the American College of Cardiology* and *European Heart Journal*.
- + Participation in more than 30 clinical trials of novel pulmonary hypertension monitoring or therapeutic strategies.

UNEXPLAINED DYSPNEA CLINIC

Our team offers comprehensive evaluation, unique diagnostic techniques and full-spectrum treatment options for this growing patient population characterized by disease of multiple common, rare or uniquely mixed etiologies that often remain unexplained through standard evaluation.

We strive to continue the Mayo Clinic legacy of applied innovation in the field. In 1950, Mayo performed the first human diagnostic cardiac catheterization resulting from improvements in instrumentation providing continuous measurements of oxygen saturation and pressure recordings. Our interdisciplinary team members include echocardiologists, exercise physiologists, neurologists specializing in myopathies, physiatrists and bariatric medicine specialists.

Diagnostic techniques

- + Comprehensive imaging center provides innovative protocols for measurement of hemodynamics and LV function.
- + Unique expertise in determining the cause of dyspnea by measuring intracardiac and pulmonary pressures, which is especially helpful for patients with normal left ventricular systolic function and the absence of severe valvular heart disease.
- + Advanced assessment of resting pulmonary mechanics.
- + Cardiopulmonary exercise testing with measurement of cardiac output, pulmonary mechanics and exercise laryngoscopy if needed.

- + Invasive hemodynamics during exercise with evaluation of shunts and high-output states.
- + Testing for myopathies including mitochondrial myopathies.
- + Targeted invasive hemodynamic evaluation based on the results of noninvasive testing and the specific patient problem. For example, choosing a radial and internal jugular access rather than the standard femoral approach for a patient who has unexplained dyspnea allows for supine bicycle exercise during the procedure. A direct left atrial pressure measurement requires a femoral approach for a potential transseptal catheterization.

Comprehensive spectrum of therapies:

- + Evaluation and treatment recommendations for athletes training for high altitude or performance enhancement
- + Collaborative care for cardiac, pulmonary and cardiopulmonary rehabilitation and training
- + Novel and conventional approaches to obesity
- + Targeted therapies for identified etiologies (HFpEF, shunts, pulmonary hypertension, pulmonary disease, myopathies)

Selected Mayo Clinic research highlights

- + “Burden of valvular heart diseases: A population-based study,” *The Lancet*, 2006, has been cited more than 700 times.
- + Studying dyspnea in exercise and at high altitude, including 2012 collaborative field studies on Mount Everest.
- + Developing inert and soluble gas techniques to measure airway blood flow, pulmonary capillary blood volume, cardiac output and alveolar-capillary conductance.

**MAYO CLINIC EVEREST EXPEDITION CLIMB:
MAY 25, 2012**



In spring 2012, Mayo Clinic cardiovascular researchers sought out field conditions of Nepal's Mount Everest—the highest mountain in the world—as a natural laboratory for studying heart disease, lung fluid retention, muscle loss, sleeping disorders and new medical technologies. Mount Everest's extreme altitude puts climbers under similar conditions to those experienced by patients suffering from heart disease, obesity or advanced age. Mayo collaborators included climbers from National Geographic, The North Face and Montana State University.



Focus on HEART FAILURE RESEARCH

For more than two decades, Margaret Redfield, M.D., has been devoted to understanding diastolic heart failure and finding effective therapies for her patients.

As a cardiology fellow in the late 1980s, Dr. Redfield was the first to show how echo Doppler could be used to diagnose diastolic heart failure. Mayo cardiologists were among the first to use echo Doppler to assess the relaxing and stiffening of the heart.

Pioneering prevalence study

Dr. Redfield utilized the Rochester Epidemiology Project, a unique medical resource at Mayo Clinic, for landmark studies that showed the diastolic form of the disease was more widespread than anyone could have guessed, accounting for more than half of all cases of heart failure.

She also went back to the lab and began to build a picture of this little-understood condition. She discovered many trends in the data. Among them: its increased status as a major public health concern, elevated frequency in women and prediction of death in even mild cases. These studies have been cited hundreds of times.

Links to pulmonary hypertension

In the cardiac catheterization lab, Dr. Redfield determined diastolic heart failure to be a cause of pulmonary hypertension, igniting national interest and a surge of research on this significant connection.

She also detected the presence of an abnormal form of a structural protein, called titin, in cardiac muscle cells that can impinge on normal contraction.

Now, in collaborations with colleagues, Dr. Redfield is establishing clinical trials to elaborate on these findings. Topics include testing drugs to improve vessel function and infusing natriuretic peptides to reduce risk of associated kidney failure.

TRAITS OF HEART FAILURE PATIENTS WITH PRESERVED OR REDUCED EJECTION FRACTION*

Trait	Reduced Ejection Fraction (N=2429)	Preserved Ejection Fraction (N=2167)	P Value	Adjusted P Value**
Age (yr)	71.7±21.1	74.4±14.4	<0.001	NA
Male sex (% of patients)	65.4	44.3	<0.001	<0.001
Body-mass index***	28.6±7.0	29.6±7.8	0.002	0.17
Obesity (% of patients)****	35.5	41.4	0.007	0.002
Serum creatinine on admission (mg/dl)	1.6±1.0	1.6±1.1	0.31	0.30
Hemoglobin on admission (g/dl)	12.5±2.0	11.8±2.1	<0.001	<0.001
Hypertension (% of patients)	48.0	62.7	<0.001	<0.001
Coronary artery disease (% of patients)	63.7	52.9	<0.001	<0.001
Atrial fibrillation (% of patients)	28.5	41.3	<0.001	<0.001
Diabetes (% of patients)	34.3	33.1	0.42	0.61
Substantial valve disease (% of patients)	6.5	2.6	<0.001	0.05
Ejection fraction (%)	29±10	61±7	<0.001	NA

Credit: Based on Mayo Clinic data as reported in The New England Journal of Medicine, July 20, 2006; 355:251-259.

* continuous variables expressed as means +/- SD.

** Age-adjusted P values.

*** Height and weight data not consistently accessible electronically over study term. During the three consecutive five-year periods of the study, percent of population for which data were available, respectively, were 9 percent, 31 percent, 83 percent.

**** Obesity defined as Body-Mass Index (BMI) = 30 or more. BMI is the weight in kilograms divided by the square of the height in meters.

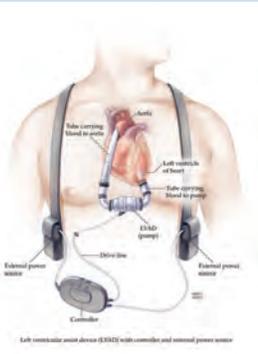
Focus on VENTRICULAR ASSIST DEVICES (VADs)

To address the growing needs of an advanced heart failure population who can benefit from mechanical circulatory assistance—with or without proceeding to transplant—specialists at Mayo Clinic’s Rochester campus formally established its mechanical circulatory assist device program in 2007.

Since then, both the demand for ventricular assist devices (VAD) and practice have grown at all three campuses. Program specialists implanted more than 100 continuous-flow VADs across Mayo’s three campuses in 2014, and the service has distinguished itself by its ability to take on challenging cases rarely considered elsewhere. Mayo Clinic Rochester is one of the few tertiary heart centers to have all three types of devices available for patients.

LVAD’s expanding indications

The patient population requiring LVAD at Mayo Clinic is unique compared to other centers. Most notably, while the majority of patients at most centers undergo LVAD implantation as a bridge to transplant, at Mayo Clinic, indication for LVAD is typically destination therapy. “Even with our unusual use pattern, compared to all the clinical trials reporting results for device therapy, our patients on average are five to 10 years older at the time of implant and have numerous comorbidities, such as compromised pulmonary and renal function,” explains John M. Stulak, M.D., transplant surgeon at Mayo Clinic in Rochester. “Nevertheless, our outcomes parallel and often exceed those reported in clinical trials.” With the technological advances of the continuous-flow models, survival outcomes have steadily improved.



In addition to having an older and sicker patient population, Mayo Clinic’s LVAD program has challenged the accepted paradigms of LVAD indications and has deployed it in select cases of dilated cardiomyopathy. Results demonstrate the feasibility based on positive functional outcomes, suggesting an expanded role for LVADs in patients with restrictive heart disease.

Diagram of LVAD pump shows components, controller and portable battery pack.

Liver-heart transplant

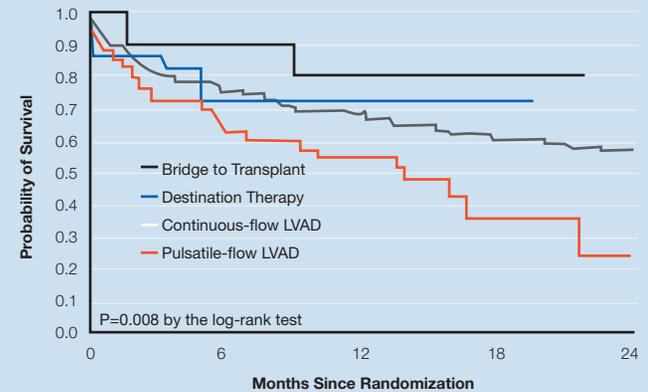
Mayo Clinic specialists on its Rochester campus employed a long-term implantable right ventricular assist device (RVAD) in a patient who then went on to undergo the first-ever transplant of liver and heart in a patient with a complex medical history of isolated right heart failure with secondary hepatic cirrhosis in need of both heart and liver transplantation. A right ventricular assist device (RVAD) was placed as a temporizing measure as bridge to transplant. However, due to the presence of multiple preformed antibodies, a conventional heart-liver transplant was likely not feasible. The patient received a liver transplant first, followed by the heart transplant. It was hypothesized that the reversed transplant sequence—liver first, heart second—allowed for the removal of preformed antibodies from the circulation. At two years, the patient had not experienced a single episode of rejection.

Percutaneous Ventricular Assist Devices/ Extracorporeal Membrane Oxygenation

In the past, percutaneous ventricular assist devices (PVAD) were the treatment of choice for carefully selected patients who are poor surgical candidates because of previous cardiac surgery or significant comorbidities. However, in the current era, these are mostly utilized in children who require mechanical support as a bridge to heart transplantation since the size of current devices preclude their use in the small patient. Extra-corporeal membrane oxygenation (ECMO) is a temporary lifesaving measure that can help stabilize a patient who is critically ill in order for that patient to progress to a durable, implantable LVAD. Mayo Clinic has a very active ECMO program for both cardiac and pulmonary support as a bridge to more definitive therapy.

Total Artificial Heart

For patients who have biventricular failure, an LVAD will not offer effective support since an LVAD primarily supports the left ventricle. For these patients, implantation of a Total Artificial Heart (TAH) is selected as a bridge for



LVAD Patient Survival: The Mayo Clinic Experience.

Data show survival for LVAD heart patients at Mayo Clinic in Rochester following continuous-flow implantation as bridge to transplant and destination therapy. Survival data are shown superimposed upon historical survival curves for pulsatile- and continuous-flow pumps from landmark trials.

FUTURE PERSPECTIVE ON LVAD

The Mayo Clinic LVAD program has implanted long-term durable devices in over 350 patients since 2007 with excellent outcomes despite the expanded indications and older patient population requiring destination therapy. We are currently involved in clinical trials involving all four devices currently available.

Another clinical trial involving another device will begin next year and Mayo Clinic will also be a part of this trial. Says Dr. Stulak: “We strive to offer our patients with advanced heart failure a wide range of options from short-term to long-term support either as a bridge to transplant or as destination therapy.”

transplantation. This device has been successfully utilized in patients with a wide array of clinical problems resulting in biventricular heart failure. This is very effective therapy as a bridge to transplant in these complex patients. We are currently taking part in two clinical trials involving this technology in order to offer this treatment to patients.

2 COMMUNITY AND COMPREHENSIVE CARDIOLOGY

SUBSPECIALTIES

- + Community Empowerment and Networking
- + Consultative CV Services Through Mayo Clinic Health System
- + International Cardiology Services
- + Ongoing Research into Science of Health Care Delivery

COMMUNITY AND COMPREHENSIVE CARDIOLOGY

Community and Comprehensive Cardiology encompasses a large, robust Midwest cardiology practice in the regional Mayo Clinic Health System of Mankato, Minnesota; La Crosse and Eau Claire, Wisconsin, and the southeastern Minnesota cities of Albert Lea, Austin, Owatonna and Red Wing, as well as selected CV outreach locations in Iowa, Minnesota, Wisconsin and Waycross, Georgia.

Network strengths

- + Cardiovascular Outreach Program in which general cardiologists are on-site at community multispecialty practices in Iowa, Minnesota and Wisconsin.
- + Televisits available for subspecialty cardiology issues.
- + Noninvasive imaging services available onsite at local hospitals.
- + Cardiologist on call 24 hours a day for emergency phone consultations.
- + Cardiology procedural and interventional services at community hospitals in Iowa, Minnesota and Wisconsin.
- + Electrophysiology specialists at community hospitals in Iowa, Minnesota and Wisconsin.
- + Electrocardiographic and echocardiographic outreach services that offer prompt, rapid interpretation.

COMMUNITY EMPOWERMENT AND NETWORKING

The focus of this innovative initiative is to share information designed to improve health and educate patients to empower them to take charge of their health by supporting changes that impact healthy living. Creating a community focused on health-conscious changes in behaviors and choices creates a powerful partner with us in achieving optimal health.

Expertise and outreach

- + A Mayo Clinic program trains primary care practitioners in issues related to heart health, including psychology. Training reduces overall cost of care by minimizing hospitalizations and referrals.
- + An education outreach effort, in collaboration with community providers, connects with patients ages 30-40 to promote heart-healthy lifestyle changes such as diet, exercise and smoking cessation.

CONSULTATIVE CV SERVICES THROUGH MAYO CLINIC HEALTH SYSTEM

Mayo Clinic Health System is a family of clinics, hospitals and health care facilities serving over 70 communities in Georgia, Iowa, Minnesota and Wisconsin. It offers a full spectrum of health care options to local neighborhoods, ranging from primary care to highly specialized care.

Expertise and assets

- + Brief consults with Mayo Clinic cardiologists by text, email or dedicated iPhone app for answers to focused cardiovascular questions
- + Informational e-consults with cardiology experts to facilitate scheduling of diagnostic tests at Mayo Clinic campus in Rochester
- + Assessment e-consults with cardiovascular specialists who perform a thorough review of patient history and test results



From left, D. Fearghas O’Cochlain, M.D., and Robert Wiechmann, M.D., colleagues from Mayo Clinic Health System in Eau Claire, Wisconsin, provide the full range of cardiac services including 24/7 angioplasty and open heart surgery.

INTERNATIONAL CARDIOLOGY SERVICES

Thousands of patients from around the world travel to Mayo Clinic locations in Arizona, Florida and Minnesota each year for medical care. Mayo’s International Patient Offices help ensure that distance, language and culture are not obstacles to receiving the best care quickly and conveniently.

Expertise and assets

- + Dedicated schedulers coordinate patients’ appointments and diagnostic tests.
- + Concierge service facilitates travel arrangements for cardiology patients and their families.
- + Translation services available in approximately 20 major languages, with others available upon request
- + Cultural traditions are respected so patient comfort and values are maintained at all times.
- + Mayo Clinic cardiologists are available 24 hours a day for follow-up questions.

Focus on **PEDIATRIC CARDIOLOGY: INTERNATIONAL EDUCATION**

EXCHANGE SCHOLARS TRAVEL BETWEEN MAYO CLINIC AND RUSSIA

Worldwide, one of every 10 children born with congenital heart disease (CHD) requires surgery in the first 30 days of life—yet less than 15 percent of children with CHD have access to medical care.

Lack of access is even more serious in the post-Soviet states. Occupying a landmass three times the size of the U.S., the Russian states have been profoundly underserved. During the Soviet era, a single pediatric cardiology center in Moscow cared for CHD patients. Mayo Clinic heart specialists have been working for more than a decade to help rectify the pediatric heart care crisis there. They provide humanitarian medical aid, teaching trips and scholar exchanges in collaboration with the nonprofit group Heart to Heart International Children's Medical Alliance, based in Oakland, California.

Mayo has hosted 10 Russian heart specialists at its Rochester, Minnesota, campus and sent multiple pediatric cardiologists from Rochester on teaching and care missions to cities such as St. Petersburg, Tomsk, Rostov-on-Don, and Kaliningrad. Combined, Mayo fellows and consultants have made more than 20 trips with Heart to Heart since 2004.

Explains Frank Cetta, M.D., pediatric cardiology chair at Mayo Clinic's Rochester, Minnesota, campus: "It is a tremendous and unusual

educational program. Unusual because the goal is to create local, long-term sustainable pediatric cardiology programs by committing to years of missions in which we train their staff on-site. And it has worked! Our colleagues in Siberia, Russia, are capable of advanced procedures such as the cone reconstruction for Ebstein's anomaly. They learned that procedure during trips to Rochester."

Mayo Clinic played a leadership role in refining valve repair techniques for Ebstein's anomaly, publishing a landmark paper in 1979. That legacy continues. In the last decade, Mayo Clinic Cardiac Surgery

Chair in Rochester, Joseph A. Dearani, M.D., and colleagues have contributed significantly to advancing the cone procedure to repair Ebstein's anomaly. Mayo Clinic remains a high-volume center of expertise for this procedure (See box).

Sharing this expertise through international educational missions is an aspect of the Mayo heart practice the pediatric cardiology team highly values, Dr. Cetta says. "It's so gratifying to experience this—to both teach and learn in this way, and to help children survive and give them the potential for long, meaningful lives."

Cardiovascular Surgery: The Mayo Clinic Experience with the Cone Reconstruction for Ebstein's Anomaly in Children

Valve repair results have historically been varied for pediatric patients with Ebstein's anomaly. To investigate this, Mayo Clinic heart surgeons reviewed results of patients < 21 years (n=84 patients) who underwent the cone reconstruction (CR) at Mayo Clinic Rochester from 2007-2012. First described by Brazilian heart surgeon J.P. da Silva, M.D., and colleagues in 2007, CR has transformed treatment.

Published in *Congenital Heart Disease*, vol. 9;3, May/June 2014, our results show:

- + 98 percent of Mayo Clinic patients had a successful CR.
- + CR is an excellent option for children and young adults with Ebstein's anomaly.
- + In most patients, CR avoids the need for valve replacement, can be performed with low early mortality, rarely requires reintervention at five-year follow-up.

Focus on THE MAYO CLINIC HEALTH SYSTEM IN EAU CLAIRE, WISCONSIN

PERFORMING >400 MINIMALLY INVASIVE VALVE REPAIR SURGERIES SINCE 2007

Cardiac valve patients' fear of the open surgical sternotomy is a powerful disincentive for seeking care due to apprehension of months of a painful recovery, respiratory compromise, possibility of an infected large wound.

But for select patients, there's an alternative: minimally invasive valve surgery through a 6-centimeter (cm) incision instead of a 25-cm incision needed to divide the sternum. Since 2007, the team at Mayo Clinic Health System in Eau Claire, Wisconsin, has had one of the few high-volume practices (n = >400 cases) in the U.S. specializing in the minimally invasive approach for aortic valve replacements, mitral valve repair or replacement, and tricuspid procedures.



Motivation for the minimal approach

Eau Claire's Robert Wiechmann, M.D., sought training in the minimal procedure a decade ago in response to the prevalence of patient apprehension over sternotomy. "Patients always say, 'I just don't want my sternum cracked or split open.' It just seemed to me that if you could keep the sternum intact and still do the procedure, then the patient was better off." The typical minimal approach recovery is several weeks—as opposed to several months—long.

Key differences

Main differences between open surgical sternotomy and the minimally invasive approach are that the latter involves:

- + **Specialized surgical tools** with longer handles, pincer grip and modified motions for manipulation, stitching, tying knots.
- + **Smaller access**, afforded by 6-cm surgical opening.
- + **New visualization methods** in which only the surgeon sees the operative field. The team watches multiple wall screens broadcasting video recorded through the surgeon's camera.
- + **An additional 30 minutes operative time.** A typical minimally invasive valve procedure lasts three hours and 30 minutes.

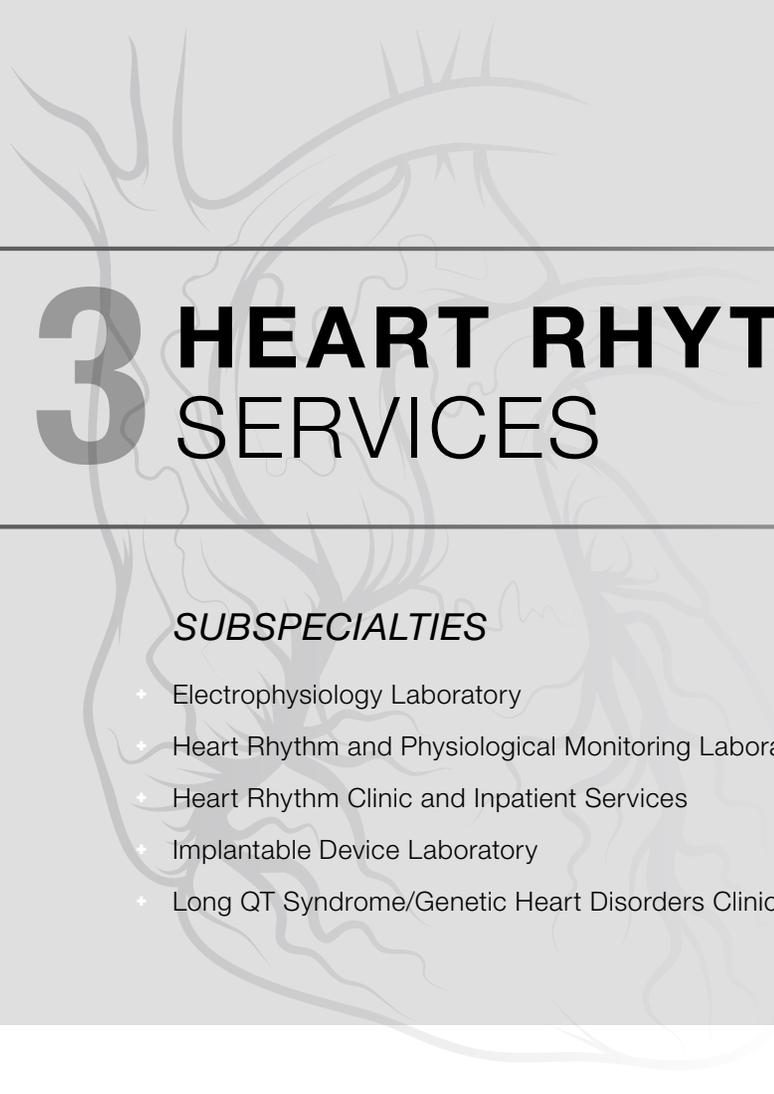
Patient selection

There are no absolute contraindications. Morbidly obese patients present medical and surgical challenges irrespective of approach, yet experienced practitioners can obtain excellent results with these patients using the minimally invasive approach. This is also true of patients who have a 50-inch or greater chest circumference.

Future direction

The team is developing a hybrid approach for valve disease patients who also have one- or two-vessel coronary artery disease. This entails back-to-back procedures of minimally invasive valve work, and then placement of one or two stents. Explains Dr. Wiechmann: "Our team is looking hard at who can be managed less invasively."





3 HEART RHYTHM SERVICES

SUBSPECIALTIES

- + Electrophysiology Laboratory
- + Heart Rhythm and Physiological Monitoring Laboratory
- + Heart Rhythm Clinic and Inpatient Services
- + Implantable Device Laboratory
- + Long QT Syndrome/Genetic Heart Disorders Clinic

HEART RHYTHM SERVICES

Our five specialized clinics and laboratories provide comprehensive care and advanced understanding through innovative research into all cardiac rhythm disorders. Streamlined lab-to-lives capabilities enable our teams of physicians and scientists to collaborate to quickly apply validated findings.

ELECTROPHYSIOLOGY LABORATORY

We perform inpatient electrophysiology studies in four biplane procedure rooms with advanced analysis and recording equipment.

Expertise and therapies

Noninvasive tests include

- + Tilt table monitoring of heart rhythms and blood pressure for diagnosis of neurocardiogenic syncope
- + Advanced 3-D mapping and imaging

Invasive tests, therapies and volumes

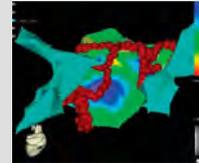
- + Radiofrequency/image-guided ablation of complex ventricular arrhythmias, performing 1,582 procedures in 2014
- + Pulmonary vein isolation for atrial fibrillation, performing >750 in 2014
- + Intracardiac ultrasound-guided electrophysiology procedures
- + ICD implants/removals, performing 796 in 2014
- + Pacemaker implants/removals, performing 1,169 in 2014
- + Biventricular pacemaker implants, performing 279 in 2014
- + Biventricular ICD implants, performing 279 in 2014

Focus on ELECTROPHYSIOLOGY



Dr. Peter Brady in the Electrophysiology Lab

Computer-generated map of left atrial activation—red dots indicate ablation sites



Dr. Willem Einthoven, the inventor of the ECG, lectured at Mayo Clinic in 1924, only two weeks after learning that he would receive the Nobel Prize. In an abstract for *The Clinic Bulletin*, Dr. Arlie Barnes wrote that Dr. Einthoven presented a series of detailed experiments and concluded that “electrical activity of the heart is always connected to mechanical activity, allowing the physician to discern pathological conditions of the heart from the ECG.”

The ECG—which was at first mysterious to physicians and scientists—is now being used in ways never imagined, such as recording intra-cardiac electrograms for ablation procedures. Mayo now performs over 3,000 electrophysiology procedures yearly.

RESEARCH IN THE WINDLAND SMITH RICE SUDDEN DEATH GENOMICS LABORATORY:

- + Genetic testing to establish genotype-phenotype relationships for more than 1,000 unrelated patients with hypertrophic cardiomyopathy (HCM).
- + Discovered 12 sudden-death-predisposing, channelopathy/cardiomyopathy-susceptibility genes that are now included in commercially available genetic tests for long QT syndrome, hypertrophic cardiomyopathy and/or postmortem sudden death test panels.
- + Comprehensive mutational analysis of the eight

most common myofilament genes in the largest assembled cohort of unrelated individuals diagnosed with HCM. The study found established mutations are present in only 38 percent of patients, *European Heart Journal*, 2005.

- + Largest documented “molecular autopsy” exploration of Sudden Unexplained Death (SUD) and Unexplained Drowning.
- + Identified one in five HCM patients to have atrial fibrillation, a strong predictor of mortality, *Journal of the American Heart Association*, 2014.

HEART RHYTHM AND PHYSIOLOGICAL MONITORING LABORATORY

Assets and Performance in 2014

- + 12-lead digital ECGs with 24/7 overread
- + 204,506 interpretations performed
- + 24/7 12-lead digital Holter mobile telemetry
- + 14,208 Holter interpretations performed
- + 4,629 event monitor recordings

In addition to Mayo Rochester, our laboratory supports over 60 outreach sites, both within the Mayo Clinic Health System and outside it.

HEART RHYTHM CLINIC AND INPATIENT SERVICES

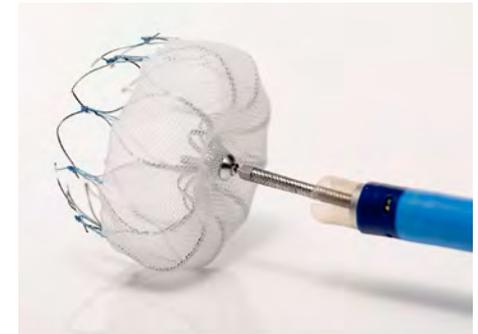
Teams specialize in the treatment of arrhythmias and congenital heart disease with the newest generations of drugs and devices for prevention of stroke, including intracardiac and epicardial left atrial appendage occlusion, and remote monitoring of arrhythmias.

Selected Mayo Clinic research highlights

- + "Stroke or transient ischemic attack in patients with transvenous pacemaker or defibrillator and echocardiographically detected patent foramen ovale," *Circulation*, 2013. Mayo researchers discovered that patients with pacemakers and defibrillators who have patent foramen ovale (PFO) are at increased risk of stroke.
- + "Prospective randomized evaluation of the Watchman Left Atrial Appendage Closure device in patients with atrial fibrillation versus long-term warfarin therapy: the PREVAIL trial," *Journal of the American College of Cardiology*, 2014. The WATCHMAN device developed at Mayo Clinic is a nitinol cage designed to close left atrial appendages for the prevention of atrial fibrillation and stroke. Clinical trials in carefully selected patients showed beneficial effects on mortality.
- + Leading the Catheter Ablation versus Antiarrhythmic Drug Therapy for Atrial Fibrillation (CABANA) trial to determine whether catheter ablation is superior to medical therapy for eliminating AF and improving quality of life. Funded by the NIH, it involves 140 international medical centers and will enroll up to 2,200 patients.
- + Initial clinical trials are testing a technique to modify pericardial ganglia as a new form of ablation treatment for AF and ventricular fibrillation (VF) that was developed at Mayo Clinic in collaboration with researchers in Ireland.
- + Noninvasive ablation via carbon and accelerated proton beams is being tested in collaboration with scientists in Germany as a potential powerful alternative to invasive catheters and radiofrequency energy. Clinical trials are anticipated to begin by 2017.

Expertise and comprehensive spectrum of therapies

- + Atrial Fibrillation Innovation Center creates and deploys the latest rhythm management advances, individualized to patient condition, lifestyle and needs
- + Leadless and subcutaneous pacing
- + Intracardiac and epicardial left atrial appendage occlusion
- + Remote monitoring of non-lethal arrhythmias in ambulatory patients



Left Atrial Appendage (LAA) Closure. The WATCHMAN is a nitinol cage that is placed via a transseptal LA endocardial sheath into the orifice of the LAA. With release after deployment, the cage radially expands with 10 active fixation anchors to maintain positioning and closure of the LAA orifice. The cage comes in five different sizes and will contour to most LAA anatomic variants. The device can be placed in patients with prior cardiac surgery. *Credit: Mayo Foundation for Medical Education and Research*

IMPLANTABLE DEVICE LABORATORY

Mayo Clinic is one of the leading medical centers for implantation of leadless pacemakers such as the Nanostim (St. Jude Medical, St. Paul, Minnesota) and the Micra transcatheter pacing system (Medtronic, Minneapolis). Both are dime-sized capsules implanted into the right ventricular apex. Our Implantable Device Laboratory is also actively engaged in the development of novel pacemakers, implantable cardioverter-defibrillators (ICDs) and cardiac resynchronization therapy (CRT).

Efforts to refine leadless pacing are warranted due to morbidity and mortality concerns associated with the leads. Implant complications typically may include bleeding, vascular damage, cardiac perforation, pneumothorax and dislodgment. Potential long-term concerns include lead fracture, malfunction, venous obstruction, tricuspid valve regurgitation and the risks associated with lead extraction. Transvenous leads are contraindicated in the presence of right-to-left shunt and in some patients with congenital heart disease.

While successful in carefully selected patients, leadless pacing has constraints. The devices are contraindicated for patients with:

- + Implantable cardioverter-defibrillators because high-voltage shocks could damage the pacemaker and the effect of the pacemaker on shock effectiveness is unknown
- + Elevated right ventricular pressures because of the potential for a higher theoretical risk of embolization
- + Mechanical tricuspid valves or inferior vena cava filters

LONG QT SYNDROME (LQTS)/GENETIC HEART DISORDERS CLINIC

Since its inception in 2000, the Mayo Clinic Long QT Syndrome/Genetic Heart Disorders Clinic has provided comprehensive evaluations for more than 1,000 unique patients and actively manages more than 500 patients with genetically proven LQTS. Together with a dedicated research laboratory, Mayo Clinic has one of the most comprehensive bench-to-bedside programs worldwide for this condition.

Minimally invasive surgical approaches

- + Left cardiac sympathetic denervation for LQTS, catecholaminergic polymorphic ventricular tachycardia (CPVT), frequent ICD shocks and other channelopathies
- + Epicardial surgery for implantable cardioverter defibrillator (ICD) using various avenues for implantation

Special focus on athletes at risk for sudden death

- + In 2014, following more than 225 athletes with LQTS or other genetic heart diseases who have chosen to continue participation in competitive sports
- + Published research revealing extremely low adverse-event rate among athletes evaluated, diagnosed, counseled and treated at Mayo Clinic reported in "Competitive sports participation in athletes with congenital Long QT syndrome," *Journal of the American Medical Association*, 2012

Focus on REMOTE MONITORING

SAVING LIVES FROM AFAR

In 1971, the world's first transoceanic transmission and interpretation of an electrocardiogram was performed by Dr. Ralph Smith, a world expert in computers in medicine. An ECG was transmitted from Sydney, Australia to Rochester where it was received by Dr. Gerald Gau. Dr. Smith made many important improvements in the ECG lab and played a key role in the introduction of the computerized CCU.



Mayo Clinic ECG lab specialists process heart test data from Australia in 1971.

The Body Guardian® device, the size of a band-aid, allows remote monitoring from anywhere in the world. It uses an algorithm developed by Mayo Clinic. It collects data on ECG, heart rate, respiratory rate and activity level. The data is transmitted over a cellular network that can be accessed on a doctor's mobile device or through a web portal.



Recent advances include the introduction of 24/7 12-lead interpretation service in 2012, which saved the life of a patient during the first week of implementation. Mayo physicians contributed to the development of the innovative Body Guardian® device, to provide remote monitoring of ECG data and multiple physiological variables.

4 ISCHEMIC HEART DISEASE PROGRAM

SUBSPECIALTIES

- + Chest Pain and Coronary Physiology Clinic
- + Coronary Artery Disease Clinic
- + Earl H. Wood Cardiac Catheterization Laboratory

ISCHEMIC HEART DISEASE PROGRAM

Our practice offers comprehensive, team-based expertise to diagnose and treat patients with all forms of ischemic disease in two specialty clinics and our advanced Cardiac Catheterization Laboratory. Mayo Clinic was among the first medical centers to pioneer diagnostic techniques via cardiac catheterization and has also pioneered the use of several catheter-based therapies.

Therapeutic options include:

- Lifestyle- and medication-based therapies
- A variety of interventional percutaneous procedures in the cardiac catheterization laboratory
- Full suite of cardiac surgical options, many of which were pioneered or refined at Mayo Clinic

Our clinical care emphasizes follow-up and rehabilitation to support healthy lifestyle and behavioral changes, recognizing the role of patient and family education in this process. Our research advances understanding of the pathophysiology of ischemia on multiple fronts to improve care, including leadership contributions we have made in developing ST-segment elevation myocardial infarction (STEMI) networks to optimize rapid reperfusion.

CHEST PAIN AND CORONARY PHYSIOLOGY CLINIC

Our team focuses on managing challenging chest pain syndromes that have eluded diagnosis, are complex or remain unresolved, such as angina that cannot be treated with standard approaches. Teams are customized to respond to individual need, and may include cardiologists, cardiovascular surgeons, radiologists, gastroenterologists, pain and anesthesia specialists and women's health specialists.

Diagnostic expertise and therapeutic options

- + Evaluating patients with atypical chest pain syndromes, coronary spasm and endothelial dysfunction, spontaneous coronary artery dissection (SCAD), and coronary artery disease (CAD) that cannot be revascularized
 - > Spinal cord stimulation
 - > Enhanced external counterpulsation (EECP)
 - > Novel drugs
- + Numerous clinical trials provide patients with access to the most recent and emerging therapies, including cell therapies

Selected Mayo Clinic research highlights

- + A 35-year PCI database with follow-up on every PCI patient has produced a rich source of data and many publications
- + Applying novel imaging modalities to study the effect of stem cell administration to patients with heart failure and CAD
- + Mayo Clinic originated the Tailored Antiplatelet Initiation to Lessen Outcomes Due to Decreased Clopidogrel Response After Percutaneous Coronary Intervention (TAILOR-PCI) trial. Its goal is to use genetic information to determine the best medication match for patients undergoing coronary angioplasty.
- + "Guided cardiopoiesis enhances therapeutic benefit of bone marrow human mesenchymal stem cells in chronic myocardial infarction," *Journal of the American College of Cardiology*, 2010.

CORONARY ARTERY DISEASE CLINIC

Mayo Clinic interventional cardiologists provide rapid access for patients needing consultation and assessment of coronary artery disease (CAD) and perform cardiac catheterizations using the entire range of percutaneous procedures available to patients with symptomatic CAD.

Expertise and assets

- + Thorough and thoughtful approach to assessment of patients with stable CAD.
 - > Evaluation and recommendations regarding stress testing, coronary angiography and revascularization.
 - > Emphasis on shared decision-making with patients and families.
- + 6 catheterization laboratories with advanced imaging systems.
 - > Proactive radiation dose management to protect both patients and caregivers.
- + 40 percent or more of interventional procedures now performed using a transradial approach, offering decreased bleeding and improved patient comfort and acceptance.
 - > Consistent evidence- and guideline-based approach to treatment of acute coronary syndrome (ACS) using standardized care process models and order sets.
- + Medical and interventional/surgical management (angioplasty and coronary bypass surgery).
 - > In 2014, our teams performed 1,147 coronary artery bypass graft (CABG) surgeries.
- + Mature and established ST-segment elevation myocardial infarction (STEMI) network focusing on providing the most rapid means of reperfusion therapy (Primary PCI and pharmacoinvasive approach).

High-volume practice

Patients are well served by our high-volume practice because it enables practitioners to critically maintain and deepen their clinical skills and experience. To further refine expert skills, all team members undergo advanced multidisciplinary training.

EARL H. WOOD CARDIAC CATHETERIZATION LABORATORY

The Dr. Earl H. Wood Cardiac Catheterization Laboratory offers comprehensive diagnostic and therapeutic procedures in state-of-the-art facilities, extending a legacy begun by pioneering Mayo cardiac physiologist, Dr. Wood, 80 years ago.

Clinical overview

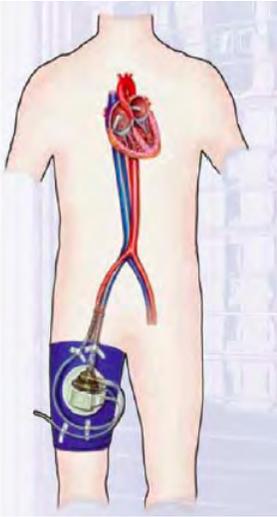


Diagram of percutaneous left ventricular assist device after insertion.

- + Our expertise ranges from diagnostic and therapeutic interventions in neonates to complex revascularization and structural interventions in elderly and high-risk patients.
- + Advanced hemodynamic studies, intravascular imaging and invasive physiologic testing are used to guide therapeutic decisions.
- + Revascularization of coronary, renal, carotid, pulmonary and peripheral vasculature, along with the catheter-based repair or replacement of heart valves are part of the daily practice.
- + New offerings in 2014 include CardioMEMS pulmonary artery pressure sensor implantation, CoreValve for TAVR, PTPA for chronic thromboembolic pulmonary hypertension, and MitraClip for mitral valve repair.
- + Opportunities to enroll in FDA-approved clinical studies provide access to new devices and emerging regenerative technologies for patients who have exhausted conventional therapies.
- + Our lab has played a leading role in institutional telemedicine efforts and is a national leader in developing life-saving cath lab capabilities at community hospitals.
- + Enhanced use of radial artery access has reduced access site complications and allowed more procedures to be carried out on an outpatient basis.
- + With over 200 peer-reviewed publications credited to cath lab consultants in 2014 and multiple new patents issued annually, the lab is consistently at the cutting edge of science and technology.
- + Cath lab-led innovation includes the development of hybrid autologous heart valves, nanotechnology-enabled stents, regenerative cellular technologies including 3-D tissue printing, and bioreactors that recreate cardiac flow conditions.
- + Ongoing clinical trials include transcatheter heart valve replacement and repair, renal artery ablation for hypertension, cell therapies and novel drug interventions for heart failure.
- + Percutaneous ventricular assist devices (PVADs) and microcirculatory axial blood flow pumps for temporary circulatory support for high-risk interventional procedures
- + High-volume center for the transradial approach
- + Expertise in the use of magnetic navigation systems (MNS) to treat highly complex coronary artery lesions
- + Use of novel retrograde lesion-crossing techniques for select cases of chronic total occlusion
- + Implantation of transcatheter aortic valves and transcatheter pulmonary artery valves—Mayo was the first in Minnesota to perform the latter
- + A multidisciplinary transcatheter aortic valve implantation (TAVI) program created through collaboration of the Valvular Heart Disease Clinic, the Division of Cardiovascular Surgery and the Interventional Cardiology Laboratory
- + Catheter-based closure of intracardiac shunts
- + Percutaneous repair of paravalvular prosthetic regurgitation
- + Left atrial appendage occlusion device evaluation, therapy, research and clinical trials such as PROTECT and PREVAIL
- + Evaluation and treatment of obstructive hypertrophic cardiomyopathy
- + Evaluation and treatment of pulmonary hypertension and congestive heart failures
- + A systematic invasive approach, hemodynamic assessment, to evaluate patients with exertional dyspnea and fatigue to discern cardiac from non-cardiac etiologies

In 2014, we performed:

- + 48 high-risk (LVAD-supported) percutaneous interventions (PCI; Impella and TandemHeart)
- + 7,388 diagnostic catheterizations
- + 743 coronary physiology studies
- + 56 balloon valvuloplasty procedures
- + 37 periprosthetic valve leak closures
- + 1,791 percutaneous interventions
- + 234 percutaneous valve procedures (Perc femoral TAVR, Melody, TMVR)

Expertise and services

Offering a full spectrum of services to pediatric and adult patients, Mayo's Cardiac Catheterization Laboratory performs more than 7,000 procedures annually through the following subspecialties:

- + Rapid reperfusion approaches in patients experiencing ST-elevation myocardial infarction (STEMI)

EARL H. WOOD CARDIAC CATHETERIZATION LABORATORY *continued*

- + Translational research into endothelial dysfunction and vascular biomarkers
- + Cell-based therapeutics for patients with refractory angina
- + Use of von Willebrand Factor activity indices as markers of disease severity in valvular heart disease and hypertrophic cardiomyopathy
- + Application of complex coronary procedure techniques to integrated management of peripheral artery disease
- + Outcomes-based quality heart care
- + Innovations in care through research, such as the evaluation of coronary endothelial function in those with symptoms of myocardial ischemia in the absence of obstructive atherosclerosis
- + Participation in international multicenter randomized clinical trials of percutaneous coronary interventions; bioabsorbable stents; platelet biology; intracoronary imaging modalities such as optical coherence tomography and near-infrared spectroscopy
- + Catheter-based technologies for the treatment of patients with structural heart disease
- + Novel advanced educational programs, such as the Structural Heart Disease Interventional Fellowship

Focus on **RAPID REPERFUSION**

Drs. Roger White, a cardiac anesthesiologist, and cardiologist Paul O'Donovan required FCC approval to use ultra-high-frequency channels to transmit ECGs from ambulances to the hospital. Minnesota political leaders Albert Quie, Hubert Humphrey and Walter Mondale assisted the Mayo physicians in their petition to the FCC. Their efforts paved the way for nationwide transmission of emergency medical data, a crucial strategy to reduce out-of-hospital mortality.

Due to continued improvements in emergency response championed by Dr. White, Rochester now has one of the highest survival rates of cardiac arrest in the U.S., more than three times the national average. Rapid transmission of ECGs is crucial to Mayo's STEMI network, one of the largest in the U.S. and a leader in reducing the time to revascularization.



Left to Right: Dr. Roger White, M.D., patient Howard Snitzer and Mayo One paramedic, Bruce Goodman, in 2011. Thanks to the availability of remote communication, Mr. Snitzer was successfully resuscitated after 96 minutes of cardiopulmonary resuscitation under the direction of Dr. White. A capnography-equipped defibrillator allowed paramedics to determine that it wasn't time to give up.

5 PREVENTIVE CARDIOLOGY PROGRAM

SUBSPECIALTIES

- + Cardiac Rehabilitation Clinic
- + Cardio-Oncology Clinic
- + Cardio-Rheumatology Clinic
- + Cardiovascular Health Clinic
- + Early Atherosclerosis Clinic
- + Sports Cardiology Clinic
- + Statin Intolerance Service
- + Stress Laboratory
- + Women's Heart Clinic

PREVENTIVE CARDIOLOGY PROGRAM

Our Preventive Cardiology Program offers care through seven clinics and multiple specialized services and laboratories to enhance both the quality and efficiency of patient care and outcomes. To reach our goal of helping create successful change and lifelong heart health, we partner with patients and their families to engage each individual in a personal mission of renewed health.

CARDIAC REHABILITATION CLINIC

Collaboration among cardiologists, physiatrists and psychologists offers an individualized treatment program to help patients recover from heart disease.

- + Phase I: pre-discharge hospital care. Evaluation, education and rehabilitation efforts begin while the patient is still in the hospital following a cardiac event.
- + Phase II: early outpatient care. Highly supervised, immediate post-hospitalization care, with classes and exercises.

Selected Mayo Clinic research highlight

- + "Impact of cardiac rehabilitation on mortality and cardiovascular events after percutaneous coronary intervention in the community," *Circulation*, 2011. Mayo Clinic investigators found that cardiac rehabilitation following percutaneous coronary intervention (PCI) is associated with a reduction in mortality of 45-47 percent.

CARDIO-ONCOLOGY CLINIC

In this specialty group, cardiologists and oncologists collaborate to manage and modify medications or chemotherapy for cancer patients with cardiovascular risks or injury.

Expertise

- + Early detection of patients at risk of cardiotoxicity from medication with early administration of cardioprotective agents.
- + Echocardiography and EMR provide early identification of cardiac injury due to chemotherapy and radiation treatments, including systolic dysfunction, asymptomatic decrease in left ventricular ejection fraction, ischemia, arrhythmia, pericarditis, and chemotherapy-induced repolarization abnormalities.
- + Noninvasive echocardiographic strain rate

imaging to detect subclinical disease by quantifying regional myocardial function.

Selected Mayo Clinic research highlight

- + "Care of the adult Hodgkin lymphoma survivor," *American Journal of Medicine*, 2011.

CARDIO-RHEUMATOLOGY CLINIC

Because people with rheumatoid conditions have a greater chance of developing cardiovascular disease, our teams have designed a clinic that addresses this linkage and the unique needs of the patient population.

Expertise

- + Early detection strategies include:
 - > New ultrasound techniques to evaluate blood vessels for the earliest signs of heart disease
 - > Detection of prolonged QT intervals, particularly among those patients with elevated erythrocyte sedimentation rate, an inflammatory marker
 - > Tests for hyperuricemia, a significant predictor of peripheral arterial disease
 - > Tests for giant cell arteritis

Selected Mayo Clinic research highlights

- + "Standard heart disease risk tools underrate danger in rheumatoid arthritis," *American Journal of Cardiology*, 2012. The Mayo Clinic team found Framingham and Reynolds risk scores underestimate the cardiovascular disease danger in rheumatoid arthritis patients.
- + In 2014 announced new findings about myocardial infarction survivors who underwent cardiac rehabilitation mediated by a smartphone-based app that recorded daily weight and blood pressure. Results showed the rehab/app group had greater improvements of cardiovascular risk factors and were less likely to be readmitted to the hospital within 90 days of discharge than the rehab-only group. Results were presented at the American College of Cardiology's 63rd Annual Scientific Session in Washington, D.C.

CARDIOVASCULAR HEALTH CLINIC

Specialists from endocrinology, physical medicine, exercise physiology and nursing help patients understand their current state of cardiovascular health and how they can reduce their risk of cardiovascular disease.

Expertise and assets

- + Enrolls up to 14,000 patients annually
- + Uses individualized approach for each patient
- + Includes comprehensive risk assessments of health-history interviews, traditional blood tests, physical exams as well as testing for inherited or genetic risk factors for heart disease
- + Offers the Mayo Clinic-developed “Cardiovascular Risk Profile”, an easy-to-understand summary of an individual’s risk factors, including blood pressure, cholesterol levels and advanced test results
- + Provides complex CV risk assessment for baseline evaluation and management consisting of:
 - > Individual stress management, weight loss, healthy eating and food preparation plans
 - > Quantitative indices of cardiovascular risk: measurement of visceral fat dual energy x-ray absorptiometry (DEXA), body shape, endothelial function (noninvasive EndoPAT test)
- + Identifies early stages of atherosclerosis with the Vascular Health Imaging Package that measures arterial health
- + Conducts risk assessments for family members, especially for those whose relative’s CV event occurred before the age of 55
- + Designs exercise plans for individuals who have had an MI or been advised to modify exercise regimens
- + Offers education and information services, including:
 - > A learning room with machines and exercise equipment where patients can develop heart-healthy habits that they can implement, even at work.
 - > Physical activity counseling
 - > Nutrition counseling
 - > Extensive and innovative patient education, including heart health videos available on YouTube and in waiting rooms

Selected Mayo Clinic research highlights

- + “Normal weight in older adults is associated with cardiometabolic dysregulation and risk for cardiovascular mortality independent of BMI and central fat distribution,” *American Journal of Cardiology*, 2013.
- + “Measurements of body mass index are not an adequate indicator for children at risk for disease,” *Pediatric Obesity*, 2014.
- + “Relationship between measures of central and general adiposity with aortic stiffness in the general population,” *Atherosclerosis*, 2014.
- + “Evaluation of functional aerobic capacity (FAC) as measured by treadmill stress-testing and mortality in normal, overweight, and obese patients,” *Mayo Clinic Proceedings*, 2013.

EARLY ATHEROSCLEROSIS CLINIC

Our teams offer comprehensive diagnostic and treatment programs for patients at risk for, or who have already developed, early atherosclerosis. The patient population includes:

Selected Mayo Clinic research highlights

- + “Proximal and distal disease locations were associated with distinctive risk factor and comorbidity profiles in patients with peripheral arterial disease,” *Journal of the American Heart Association*, 2013.
- + “Patients with poorly compressible leg arteries have worse survival than those with normal ankle-brachial index or peripheral arterial disease,” *Journal of American College of Cardiology*, 2012.

- > Men under age 55 and women under age 65 with any manifestation of atherosclerosis including heart attack, stroke and peripheral arterial disease
- > Individuals with a family history of early atherosclerosis who are asymptomatic
- > People with elevated levels of disease biomarkers

Expertise

- + Administering cardiovascular risk panel biomarkers that include C-reactive protein (CRP), fibrinogen, lipoprotein (a) and homocysteine
- + Conducting arterial tests that evaluate endothelial function, arterial stiffness, and degree of carotid plaque occlusion
- + Conducting CT scans to detect calcium in the arteries of asymptomatic patients with a family history of heart disease

SPORTS CARDIOLOGY CLINIC

Cardiologists consult with physiatrists, nutrition and physical medicine and rehabilitation to advise athletes on safe training and exercise programs. Patients include high-performance athletes, adolescent athletes ages 15 or older, and less-competitive exercisers who have cardiorespiratory symptoms on exertion.

Expertise

- + Medical assessment for clearance to continue sports participation after cardiovascular surgery or a cardiac event
- + Evaluation of symptoms such as chest pain, palpitations or shortness of breath with activity
- + Evaluation of unexplained deterioration in athletic performance

STATIN INTOLERANCE SERVICE

Our teams focus on expert diagnoses, risk stratification and treatment of patients with statin-associated side effects who are in need of continued statin therapy.

Expertise

- + Diagnosis of statin intolerance includes genetic tests, percutaneous muscle biopsy, muscle strength test, creatine kinase and vitamin D blood levels, and renal and thyroid function testing.
- + Treatment with statin modification or implementation of additional cholesterol-reducing strategies.

STRESS LABORATORY

Our Integrated Stress Testing Center performs cardiac stress testing at two sites to accommodate both admitted patients and outpatients. Testing modalities include standard ECG exercise testing, cardiopulmonary exercise testing, stress echocardiography and nuclear stress testing. We make it a priority to help referring physicians determine the appropriate test needed to answer a clinical question, arrange consultation in cardiology and provide other services as needed in order to fully understand each individual patient's heart performance.

In 2014, we performed:

- + 32,700 stress and exercise electrocardiograms
- + 10,236 stress and exercise myocardial perfusion imaging procedures
- + 5,465 exercise ECGs

WOMEN'S HEART CLINIC

Our specialists conduct risk assessments, heart evaluations, comprehensive treatment and education for as many as 5,000 pre- and postmenopausal women a year who are at risk for—or diagnosed with—cardiovascular disease.

Expertise

- + Accepts referrals for patients with unrelenting chest pain and other difficult-to-treat symptoms
- + Tests for uncommon syndromes more prevalent in women, including spontaneous coronary artery dissection
- + Prioritizes timely communication with patients' local physicians to relay test results and discuss findings

Selected Mayo Clinic research highlights

- + One of nine centers leading the Kronos Early Estrogen Prevention Study (KEEPS) exploring issues relevant to menopausal women, with cardiovascular arm investigating hormone therapy and the risk of heart disease and stroke
- + “Contrast stress echocardiography (CSE) testing results on cardiovascular risk behaviors in postmenopausal women presenting with chest pain symptoms,” *Journal of Women's Health*, 2014.
- + “Coronary hemodynamics, sex-related differences in fractional flow reserve-guided treatment,” *Circulation: Cardiovascular Interventions*, 2013, reporting Mayo Clinic findings on long-term outcomes of FFR-guided PCI differences between women and men. Our investigators conclude the data suggest that a sex-based treatment strategy is necessary to further optimize prognosis of coronary artery disease patients.

Focus on MAYO CLINIC'S FLORIDA CAMPUS

SCIENTIFIC LEADERSHIP

Scientific leadership is an important Mayo Clinic value aimed at collaborating with peers to advance patient care through policy and practice. Dozens of Mayo Clinic M.D.s and Ph.D.s chair scientific panels and serve on committees around the world to apply their expertise in evaluating data, assessing public health needs and helping draft guidelines to improve clinical practice and patient health. This American Heart Association

Scientific Statement on Exercise Standards for Testing and Training, chaired by Gerald F. Fletcher, M.D., Mayo Clinic Florida cardiologist, and published in *Circulation* in 2013, is just one example of Mayo's commitment to participating in the larger scientific community.

Contributing to scientific statements on heart health is highly valued by Mayo Clinic heart specialists.



6 STRUCTURAL HEART DISEASE PROGRAM

SUBSPECIALTIES

- + Congenital Heart Disease Clinic
- + Heart Brain Clinic
- + Hypertrophic Cardiomyopathy Clinic
- + Marfan Syndrome and Thoracic Aortic Aneurysm Clinic
- + Pericardial Disease Clinic
- + Valvular Heart Disease Clinic and Inpatient Services

STRUCTURAL HEART DISEASE PROGRAM

Mayo Clinic is recognized internationally for its pioneering contributions to the diagnosis, treatment and rehabilitation of patients with structural heart disease. In 2014, our leadership and contributions to the field remained strong and were recognized widely, including such distinctions as the naming of a Mayo Clinic cardiologist to chair the AHA/ACC writing group to help develop guidelines on valvular heart disease.

CONGENITAL HEART DISEASE CLINIC

Our Congenital Heart Disease (CHD) Clinic is one of the largest in the country. We specialize in expert diagnoses and developing individualized treatment plans for continuity of care across a spectrum of patients and conditions, and throughout the lifespan of patients with CHD. Our multidisciplinary care teams are expertly trained in echocardiography, imaging, MRI, cardiac catheterization, management of arrhythmias, contraception counseling, management of pregnancy and delivery, cardiac surgery and pediatric cardiology.

Selected Mayo Clinic research highlights

- + Documenting natural history of post-surgical care of patients with hypoplastic left heart syndrome (HLHS) with the long-term goal of developing regenerative strategies to strengthen and augment the right ventricular muscle of the single-ventricle heart following surgical palliation
- + Cell-based cardiac regeneration studies to validate the use of umbilical cord blood as a source of autologous cells for the purpose of cardiac repair of congenital heart disease

Expertise and metrics

- + More than 6,000 patients and 775 congenital heart disease (CHD) surgeries in 2014
- + 40 percent of our patients with CHD present following four or more unsuccessful surgeries elsewhere
- + 60 percent of our patients are more than 40 years of age
- + Mortality is less than 5 percent, even in high-risk, complicated cases and multiple repeat surgeries
- + Leading clinical and surgical expertise in Ebstein's anomaly, involving repair of the tricuspid valve and interventions for arrhythmias—having performed repairs on more than 600 patients
- + Expertise in other uncommon cardiac lesions: congenitally corrected transposition and more than 1,000 patients with coarctation of the aorta
- + Highly experienced in management of pregnancy and childbirth for patients with CHD

HEART BRAIN CLINIC

Opened in fall 2015, this new multidisciplinary approach between the Division of Cardiovascular Diseases and Department of Neurology focuses on patients with either patent foramen ovale (PFO) or atrial fibrillation (AF) and who have had a stroke or transient ischemic attack (TIA).

Expertise

- + Patients are jointly seen by specialists from Neurology and Cardiology in this clinic.
- + Dedicated weekly clinic with exclusive focus on this patient population.
- + Consultation with interventional or electrophysiology consultants as warranted for patients being considered for left atrial appendage closure who have not had a TIA or stroke.

HYPERTROPHIC CARDIOMYOPATHY CLINIC

We provide highly individualized management for patients with hypertrophic cardiomyopathy (HCM), including expert surgical treatment.

Expertise and metrics

- + Treated more than 4,000 patients with hypertrophic cardiomyopathy (HCM)
- + 238 myectomy/myotomy procedures in 2014
- + Developed a septal myectomy technique to relieve septal ablation in adults and children with left-ventricular outflow tract obstruction, performing approximately 200 annually
- + Other treatment techniques, including percutaneous septal reduction therapy with septal alcohol ablation and surgical placement of implantable cardioverter defibrillator (ICD)
- + Genetic testing of more than 1,000 unrelated patients with HCM

Selected Mayo Clinic research highlights

- + "Atrial fibrillation in hypertrophic cardiomyopathy: prevalence, clinical correlations, and mortality in a large high-risk population," *Journal of the American Heart Association*, 2014. A Mayo Clinic study of a large referral HCM patient population (n=3,673) found one in five to have AF, and that AF is a strong predictor of mortality, even after adjustment for established risk factors.
- + "Risk of death in long-term follow-up of patients with apical hypertrophic cardiomyopathy," *American Journal of Cardiology*, 2013. Mayo research identified mortality risk factors in apical hypertrophic cardiomyopathy, suggesting that apical HCM has different prognostic implications for affected women than affected men.
- + Numerous articles in top-tier journals focusing on septal myectomy.

MARFAN SYNDROME AND THORACIC AORTIC ANEURYSM CLINIC

We offer an integrated medical, genetic and surgical team approach with specialized testing for diagnosis and medical/surgical treatment for patients with Marfan syndrome and related disorders involving enlarged aortas.

Expertise and metrics

- + 293 thoracic aortic aneurysm or dissection repairs in 2014.
- + Approximately 200 annual referrals for Marfan syndrome and related disorders involving enlarged aortas.
- + Broad, sensitive diagnostic expertise, including distinguishing Marfan syndrome from similar conditions, such as Loeys-Dietz syndrome.
- + Collaboration with experts in genetic testing, echocardiography, vascular imaging (including CT and MR) and surgery for repair of the ascending aorta, and to help patients determine plans for lifelong management and disease surveillance.
- + Excellent surgical outcomes. Our teams performed more than 70 aortic root replacement surgeries for patients with Marfan syndrome between 2004-2012, with zero percent early mortality.
- + Collaboration with specialists treating related medical conditions, such as spine and eye complications.

Selected Mayo Clinic research highlights

- + Involved in many multi-center clinical trials, with strong participation. Mayo Clinic enrolled more patients than any other center in NIH study comparing standard valve repair and valve-sparing aortic valve repair.
- + Epidemiological and adverse event research underway related to bicuspid aortic valve, affecting nearly 2 percent of population
- + Studying gene mutations that result in aneurysms of the ascending aorta

PERICARDIAL DISEASE CLINIC

Cardiologists, cardiac surgeons, rheumatologists and infectious disease specialists collaborate to evaluate and treat patients with pericardial disease, including recurrent pericarditis, pericardial effusion, constrictive pericarditis and asymptomatic pericardial cysts.

Selected Mayo Clinic research highlights

- + Ongoing clinical trials include:
 - > Prospective trial to reduce the occurrence of post-pericardiotomy syndrome, such as atrial fibrillation or pericarditis that occur in 30 percent of patients who undergo cardiac bypass or valve surgery
 - > Investigating medical therapy vs. surgical pericardiectomy as optimal treatment for recurrent pericarditis
 - > Strategies for management of temporary constrictive pericarditis, which occurs in up to 20 percent of patients who undergo cardiac surgery

Expertise

- + At all three locations combined, 73 performed in 2014 for patients whose disease required surgical management.
- + Expertise in diagnosis with refined knowledge of imaging, including echocardiography, CT, MRI, PET.

Focus on MAYO CLINIC'S ARIZONA CAMPUS

NEW PERCUTANEOUS, IMPLANTABLE DEVICE FOR MITRAL REGURGITATION

Mitral valve disease can be challenging to treat because of its often-insidious progression. Untreated, severe mitral regurgitation (MR) progresses to left ventricular dysfunction (LVAD) and heart failure, with yearly mortality of approximately 5 percent in symptomatic patients. Medical therapies may reduce symptoms, but they do not reduce mortality figures. Surgical mitral valve repair or replacement has long been the definitive treatment.

However, recent technological advances now expand options to include a percutaneous approach to attach a permanent implantable device to the mitral valve leaflets to modify anatomy and restore function. Called the MitraClip (Abbott Vascular, Santa Clara, California), the 15-millimeter (mm) by 5mm, cobalt-chromium device is delivered by catheter to the leaflets.

All Mayo Clinic heart campuses offer the MitraClip device. At the Structural Heart Clinic at Mayo Clinic Arizona's campus clinic, physicians have found its availability to be especially important for elderly patients too frail to risk traditional surgical repair. The procedure is currently performed in patients with structural mitral valve abnormalities. However, other high-risk patients with functional mitral regurgitation are also being evaluated, and indications for the procedure may expand in the future.

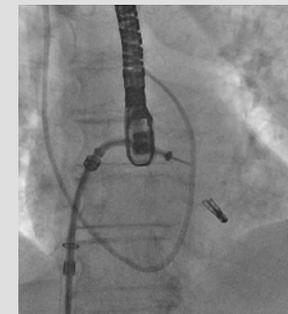
Advanced heart centers that emphasize multidisciplinary collaboration and expertise are especially well suited to perform this procedure successfully. At Mayo Clinic, specialists involved include cardiac interventionalists,

cardiothoracic surgeons, echocardiographers and anesthesiologists.

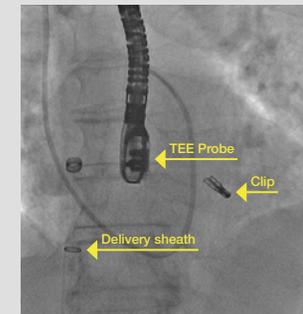
Once placed, the MitraClip clips the anterior, middle and posterior mitral leaflets together to create a double orifice valve. Transesophageal echocardiography (TEE) is used during the procedure. If surgery is later indicated, the clip can be surgically removed.



Mitral clip delivery



Mitral clip deployment



Mitral clip in place

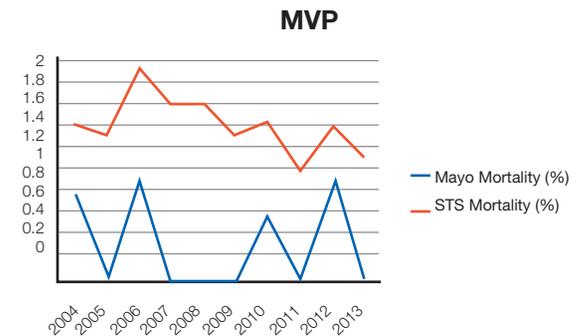
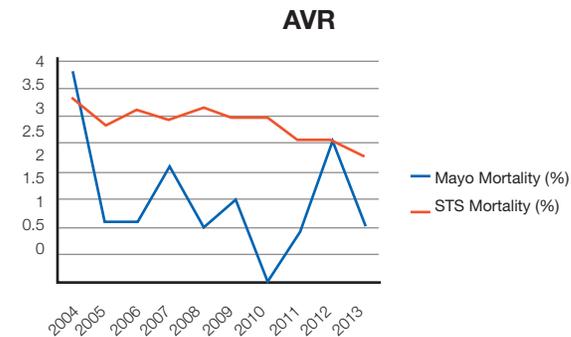
VALVULAR HEART DISEASE CLINIC AND INPATIENT SERVICES

Mayo Clinic is one of the largest medical centers in the United States for heart valve surgeries. We offer advanced diagnostic testing and superior results offering unique surgical therapies such as less-invasive, robot-assisted mitral valve repair and catheter-based therapies, including transcatheter heart valves and periprosthetic leak closure devices.

Expertise and assets

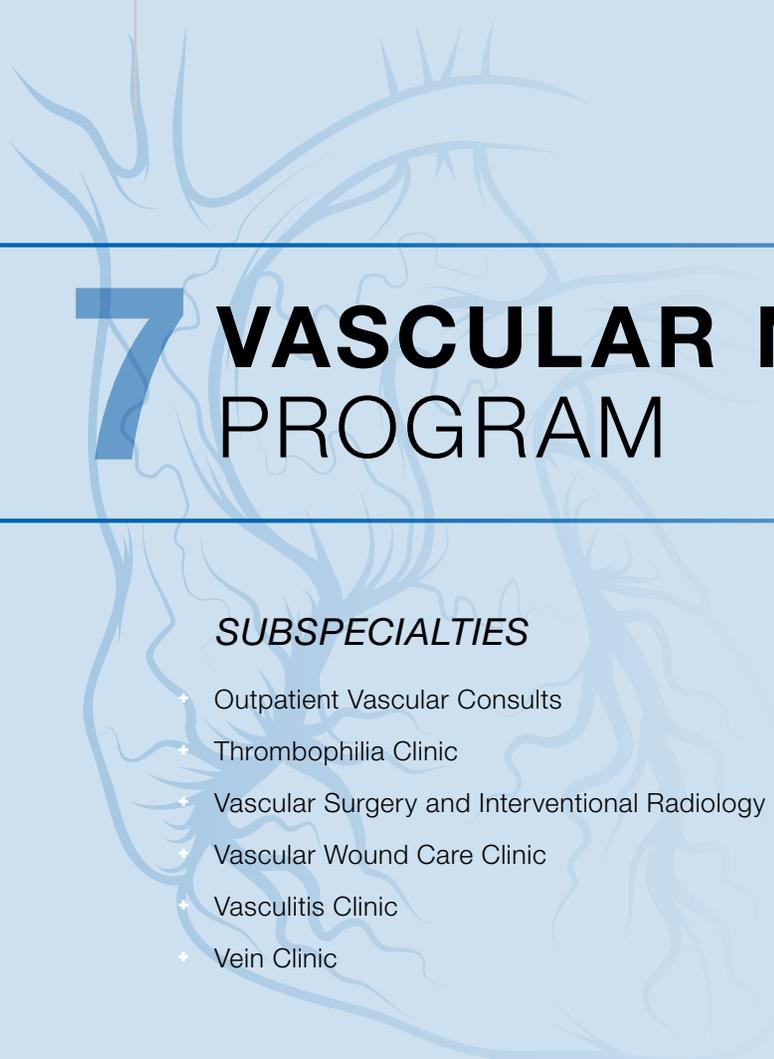
- + Specializing in complex heart valve surgeries, including high-risk cases and patients who have undergone previous heart valve surgery
- + Advanced imaging, including quantitative and 3-D transthoracic echo or transesophageal echo (TEE), computed tomography (CT), magnetic resonance (MRI) and ultrasound
- + Robotic mitral valve repair and thoracoscopic surgery
 - > Robotic MV repair (with da Vinci surgical robot) now available for severe mitral regurgitation (MR), including asymptomatic patients with preserved LV function
- > Transcatheter aortic valve replacement (TAVR) for aortic stenosis in selected patients at high risk of open-heart surgery
- > Expertise with closed-chest robotic instrumentation that has the same safety, efficacy and long-term durability as standard valvuloplasty techniques
- > 100 percent success rate for degenerative mitral prolapse in the robotic series to date; <1 percent reoperation rate
- + Catheter-based paravalvular leak closure in patients after prior valve replacement surgery

Right, top to bottom. In the decade between 2004 and 2013, Mayo Clinic mortality for aortic (AVR) and mitral valve prosthesis (MVP) replacement surgery procedures were below the Society of Thoracic Surgeons' database averages.



Selected Mayo Clinic research highlights

- + Leading the Perceval multicenter clinical trial to test the insertion of the sutureless Perceval aortic valve, allowing for shorter operative times using minimally invasive approaches.
- + Increased survival rates among otherwise inoperable patients with severe aortic stenosis who participated in the Placement of Aortic Transcatheter Valve Trial (PARTNER). The clinical trial evaluates a new balloon-expandable cardiac valve placed through the transfemoral or the transapical route, without the need for a median sternotomy.
- + “Association between early surgical intervention versus watchful waiting and outcomes for mitral regurgitation due to flail mitral valve leaflets,” *Journal of the American Medical Association*, 2013. Mayo Clinic-led multi-center study of 1,021 patients showed timely mitral valve repair preferred over watchful waiting in individuals with severe mitral valve regurgitation due to leaflet prolapse.
- + “Bicuspid aortic valve: identifying knowledge gaps and rising to the challenge from the International Bicuspid Aortic Valve Consortium (BAVCon),” *Circulation*, 2014. The Mayo Clinic team identified knowledge gaps and proposed a roadmap to discovery based on current imaging, molecular biology and genetic tools.



7 VASCULAR MEDICINE PROGRAM

SUBSPECIALTIES

- + Outpatient Vascular Consults
- + Thrombophilia Clinic
- + Vascular Surgery and Interventional Radiology
- + Vascular Wound Care Clinic
- + Vasculitis Clinic
- + Vein Clinic

VASCULAR MEDICINE PROGRAM

Our highly specialized, integrated approach provides patients with state-of-the-art diagnosis, prevention, treatment and follow-up care for disorders related to the arteries, veins and lymphatic system. In 2014 in Rochester, Minnesota, we served more than 44,000 patients through our many outpatient specialty clinics and services.

OUTPATIENT VASCULAR CONSULTS

We treat patients of all ages with the full spectrum of arterial, venous and lymphatic disorders.

Expertise and assets

- + Approximately one dozen fully trained vascular specialists work on a rotating schedule so that two evaluate and treat the 10 to 14 new patients each day. More than 3,300 unique patients require vascular medicine consultation each year, nearly equally divided between arterial and venous disorders.
- + Highly experienced diagnosticians who find that approximately 10 percent of referred patients have lymphatic disease.

Diagnostic resources

Vascular Physiology Laboratory

- + Eight fully equipped rooms are dedicated for vascular physiologic studies, with three for lower extremity arterial, three for venous and two for upper extremity arterial evaluation.
- + Fully trained vascular technicians are RVT-certified.
- + Each year, over 5,000 patients undergo vascular testing such as ankle-brachial indices, exercise testing of the lower extremities, transcutaneous oximetry, laser Doppler fluximetry and upper extremity arterial testing including thermal provocative testing and venous plethysmography.

Vascular Ultrasound Laboratory

- + 10 examination rooms are fully equipped with state-of-the-art Acuson Sequoia ultrasound machines.
- + 10 vascular radiologists and 40 sonographers extensively trained in vascular ultrasound and RVT-certified.
- + Studies include aneurysm screening, carotid ultrasound, venous ultrasound for deep venous thrombosis and venous incompetence, vascular bypass graft surveillance and renal ultrasound.
- + Located near the Vascular Physiology Laboratory for easy access.

Selected Mayo Clinic research highlights

- + Defining the epidemiology, risk factors and natural history of peripheral arterial occlusive disease in a community-based population, publishing findings in multiple journals, including *Atherosclerosis*, *Journal of the American College of Cardiology*, *Circulation* and *Mayo Clinic Proceedings*
- + Defining the impact of genetic polymorphisms on peripheral arterial occlusive disease, publishing results in *Circulation*, *Mayo Clinic Proceedings*, *Journal of the American Heart Association* and *Journal of the American Medical Informatics Association*
- + Determining guidelines for PAD management published in *Circulation*, *Journal of the American College of Cardiology*, *Vascular Medicine* and *Journal of Vascular Surgery*

THROMBOPHILIA CLINIC

A multidisciplinary group in this clinic provides comprehensive care for patients with thrombophilia, as well as an academic nucleus for education and research in thrombotic disorders.

Expertise and assets

- + 9 specialists from Cardiovascular Diseases, Hematology/Oncology, and General Internal Medicine evaluate, prevent and manage acute venous thrombotic disorders and complex arterial thrombotic disorders, as well as manage and counsel patients receiving chronic anticoagulation who require an invasive procedure.
- + Nurse practitioner supervisor, five registered nurses and four nurse practitioner/physician's assistants manage acute and chronic anticoagulation.
- + In 2014, our Rochester campus managed more than 4,000 unique outpatient visits.
- + Other services include recommendations for thromboprophylaxis in high-risk patients and chronic anticoagulation clinic services (both in-house and "home INR" monitoring systems using point-of-care testing).
- + Funded by the Centers for Disease Control, we complete the Thrombophilia Clinic Registry for every patient episode of care, a boon for clinical research in thrombosis and anticoagulant delivery that is aided by the

close proximity of vascular ultrasound facilities to enroll eligible patients in clinical trials of novel antithrombotic therapies. Patients with venous thromboembolism are enrolled into epidemiological and laboratory (including molecular) studies of thrombophilia.

Diagnostic techniques and resources

The Special Coagulation and DNA Diagnostic Laboratory is an international reference laboratory devoted to the evaluation of patients with complex thrombotic and hemorrhagic disorders.

- + 3 Vascular Medicine consultants with joint appointments in the Division of Hematology.
- + Patients with thrombotic events are quickly and efficiently transported to the adjacent Thrombophilia Clinic for prompt anticoagulation implementation.

Selected Mayo Clinic research highlights

- + Defined the epidemiology of venous thromboembolism through community-based studies, publishing results in *Blood*, *Circulation*, *Archives of Internal Medicine*, *Annals of Internal Medicine*, *Journal of Thrombosis and Haemostasis*, *Thrombosis and Haemostasis* and *Thrombosis Research*
- + Defined the epidemiology of atypical organ vein thrombosis, publishing findings in *Journal of Thrombosis and Haemostasis*, *Stroke*, *Neurology*, *Mayo Clinic Proceedings* and *Journal of Gastroenterology*
- + Defined the current practice of bridging for periprocedural anticoagulation, publishing results in *Circulation*, *New England Journal of Medicine*, *Journal of Thrombosis and Haemostasis*, *Thrombosis and Haemostasis*, *Thrombosis Research*, *Arteriosclerosis*, and *Thrombosis and Vascular Biology*

VASCULAR SURGERY AND INTERVENTIONAL RADIOLOGY

Each year, specialists on Mayo Clinic's Rochester campus in vascular surgery perform approximately 1,800 procedures. Of these, approximately 60 percent are endovascular procedures, and the remainder are open surgeries. In 2014, we had more than 4,600 outpatient visits.

Expertise and assets

- + Full-continuum surgical expertise across all endovascular and open procedures
- + Collaborative practice poised to respond with surgical options appropriate to each patient's individual type of disorder, classification stage and complexity of disorder, timing of interventions and prognosis for long-term survival
- + Research leaders on advanced aortic repairs, addressing issues such as discovering anatomic or physiological features to help predict the patient who will have an uncomplicated dissection and the optimal timing and type of interventions

VASCULAR WOUND CARE CLINIC

This multidisciplinary clinic is staffed by specialists from vascular medicine, internal medicine, preventive medicine, undersea and hyperbaric medicine, physical medicine and rehabilitation to care for patients with arterial, venous, traumatic and neurotrophic wounds.

Expertise and assets

- + Cared for more than 3,500 outpatient visits annually in Rochester alone.
- + Occupying 1,695 square feet, the Gonda Vascular Center is equipped with the most advanced, high-performance technologies.
- + 88 percent healing success rate.
- + 18 weeks average time to heal a wound.
- + Hyperbaric oxygen chamber.
- + Cultured skin graft application.
- + Total contact casting.
- + In-house growth factor.
- + Ultrasonic dermal debridement.
- + Intermittent pneumatic compression.

Diagnostic Techniques:

- + Noninvasive arterial studies
- + Noninvasive venous studies
- + Foot pressure analysis

Selected Mayo Clinic research highlights

- + “Noninvasive arterial studies including transcutaneous oxygen pressure measurements with the limbs elevated or dependent to predict healing after partial foot amputation,” *American Journal of Physical Medicine and Rehabilitation*, 2013.
- + “The use of elevation and dependency to enhance the predictive value of transcutaneous oxygen pressure measurements in the assessment of foot amputation healing,” *PM&R: The Journal of Injury, Function, and Rehabilitation*, 2010.
- + “Expedited wound healing with noncontact, low-frequency ultrasound therapy in chronic wounds,” *Advances in Skin and Wound Care*, 2008.

VASCULITIS CLINIC

A rheumatologist and a vascular medicine specialist care for patients with large-, medium- and small-vessel vasculitis two mornings per week. In 2014, approximately 600 patients received care at the Vasculitis Clinic in Rochester, Minnesota.

Expertise and assets

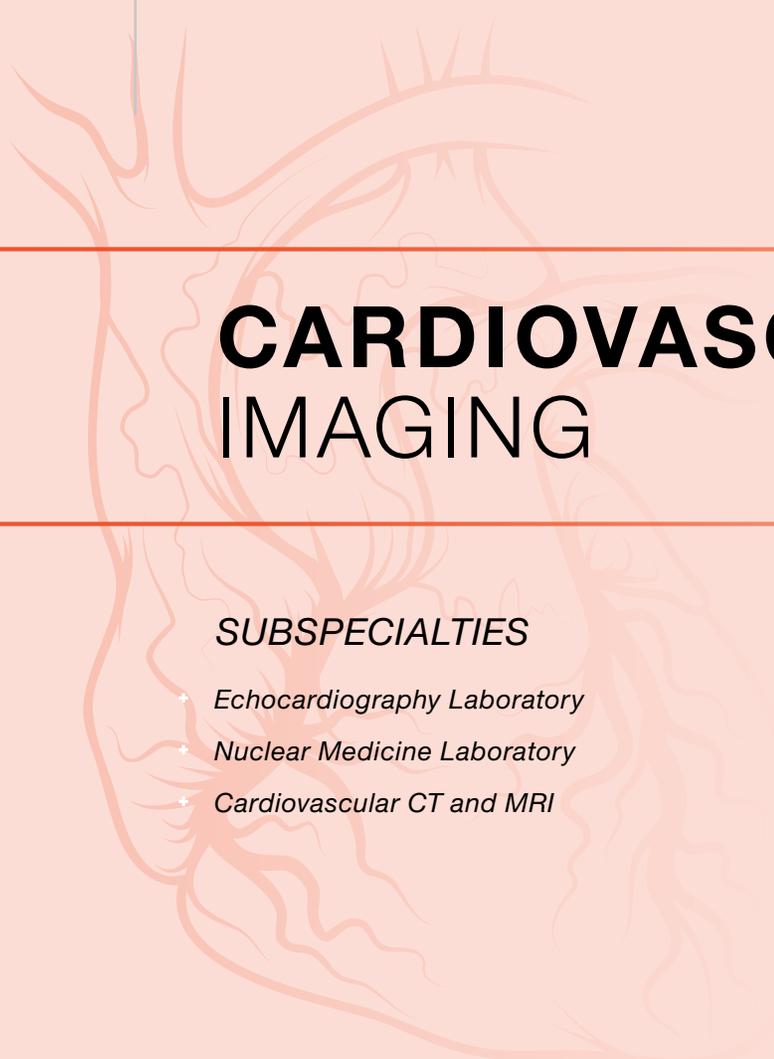
- + Multidisciplinary approach to efficiently address immunologic, wound care and revascularization issues.
- + Noninvasive vascular testing, vascular surgical and interventional radiological consults are obtained expediently in this setting.

VEIN CLINIC

Specialists in vascular medicine, vascular surgery, vascular interventional radiology and dermatology provide prompt treatment using the latest techniques for patients with varicose veins.

Expertise and assets

- + Provide sclerotherapy for spider veins
- + Provide sclerotherapy and foam sclerotherapy for small and moderate-sized varicose veins
 - › Offer radiofrequency and laser ablations of the great and small saphenous veins, accessory veins and perforator veins
- + Duplex ultrasound evaluation for varicose veins



CARDIOVASCULAR IMAGING

SUBSPECIALTIES

- ✦ *Echocardiography Laboratory*
- ✦ *Nuclear Medicine Laboratory*
- ✦ *Cardiovascular CT and MRI*

CARDIOVASCULAR IMAGING

Advanced training and imaging technologies in all major modalities of cardiac imaging are fundamental to Mayo Clinic's team-based approach to patient care. Supported by highly focused research into new and better ways to image anatomy, processes and change over time, our cardiac imaging subspecialties also offer robust educational courses.

ECHOCARDIOGRAPHY LABORATORY

Our Rochester, Minnesota, Cardiovascular Ultrasound Imaging and Hemodynamic Laboratory (Echo Lab) is the largest clinical, educational and research echocardiographic lab of its kind in the world. For both adult and pediatric patients the clinical excellence, quality and comprehensiveness of our exams are well known and highly respected. We maintain this performance level despite a high-volume clinical practice with over 60,000 echocardiograms performed by Rochester staff in 2014. Visitors from around the world come to our lab to observe our state-of-the-art facilities and practices.

Expertise and assets

- + Our excellent and highly skilled faculty and allied health staff.
- + State-of-the-art equipment.
- + Echocardiography Level III-trained experts performing outpatient and inpatient studies, including transthoracic, transesophageal, exercise and dobutamine stress studies.
- + Active Echocardiography Core Lab that provides echo interpretation for numerous multicenter research studies funded by the National Institutes of Health, foundations and others.
- + Intraoperative echocardiograms.
- + Support for >50 research studies each year that involve echo.
- + Our unique approach of interpreting images with the patient still present allows additional images to be performed expediently when recommended.
- + Unusual degree of specialization, such as expertise in congenital issues.

Outreach and education

- + More than 150 publications are authored by our lab teams each year.
- + Broad educational reach teaching many learners, including our cardiology fellows, research fellows, fellows in critical care and anesthesiology, and the sonographers in our school.
- + Weekly educational conferences.
- + Proven pedagogy and well-developed curriculum.
- + Staff members involved in ~15 Mayo Clinic CME courses that predominantly feature echo.

Procedural volumes for 2014, all sites combined

- + 78, 828 Adult TTE
- + 7,661 Congenital TTE and TEE combined
- + 2,499 Adult Intraoperative TEE
- + 5,844 Adult TEE
- + 139 Pericardiocentesis
- + 203 Fetal Echocardiograms
- + 15,840 Stress Echocardiograms
- + 696 Research Echocardiograms
- + 1,109 Miscellaneous
- + **112,819 Total combined volume for 2014, enterprise-wide**

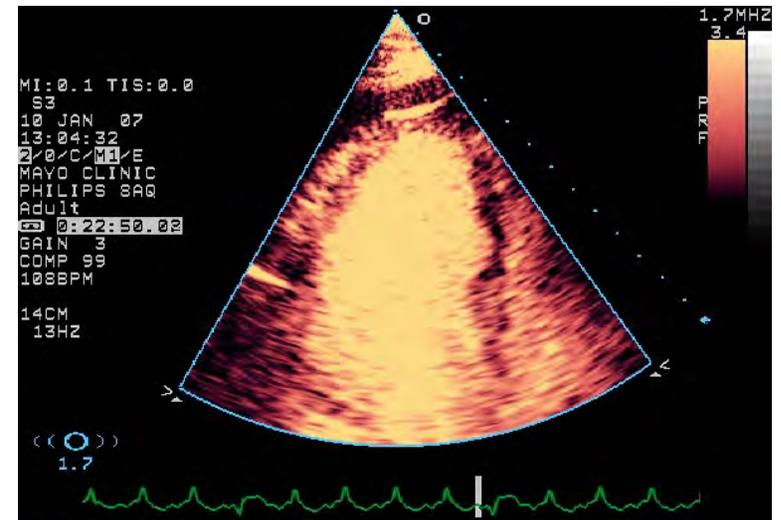


Figure 1. In the top right image, echo microbubble contrast is used to enhance endocardial borders of the left ventricle. Incidentally noted is a perfusion abnormality of the mid-septum in this patient with coronary artery disease.

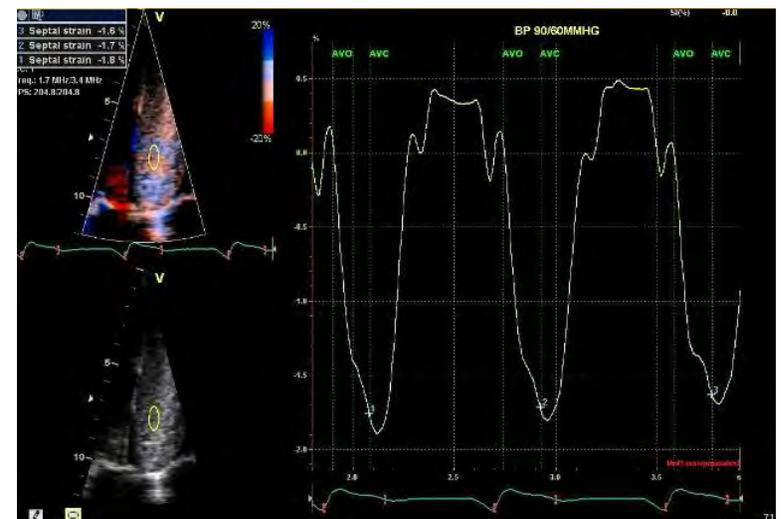
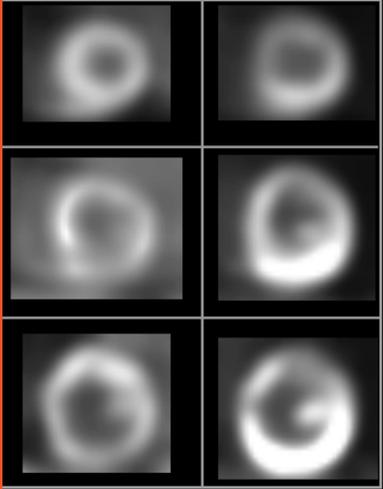


Figure 2. In the bottom right image, strain imaging measures myocardial deformation and is used here to characterize and quantify preclinical myocardial dysfunction in a cardio-oncology patient receiving chemotherapy.

NUCLEAR CARDIOLOGY LABORATORY

Our Nuclear Cardiology Laboratory offers the highest-quality patient-centered diagnostic services with special emphasis on myocardial perfusion and metabolic imaging using state-of-the-art SPECT (Single Photon Emission Computed Tomography) and PET (Positron Emission Tomography) technologies. With expertise in these technologies, our highly skilled faculty and dedicated allied health staff ensure outstanding quality in all aspects of clinical studies and engage in educational and research endeavors.



PET viability imaging demonstrating a large area of perfusion-metabolism mismatch consistent with hibernating myocardium.

Expertise and assets

- + Level III-trained nuclear cardiologists and nuclear medicine specialists
- + Dedicated allied health staff
- + Access to state-of-the-art equipment and facilities including two on-site cyclotrons, six PET/CTs, one PET/MRI system, nine conventional SPECT and SPECT/CT systems, two cardiac-only high-sensitivity SPECT cameras, and mobile systems
- + Dual-consensus reading with nuclear cardiologist and nuclear medicine specialist/radiologist for all nuclear cardiology studies, bringing multidisciplinary expertise to help care for patients
- + Comprehensive suite of advanced studies and services, including:
 - > SPECT and PET myocardial perfusion imaging
 - > Absolute quantification of myocardial blood flow
 - > Myocardial viability assessment
 - > Assessment of cardiac sarcoidosis
 - > Identification of cardiac amyloidosis
 - > Measurement of LV function
 - > Phase analysis
 - > Calcium scoring

Education

- + Dedicated faculty provide broad education for many different learners, including our cardiology and radiology fellows, research fellows, internal medicine and radiology residents, and allied health staff.
- + Program is available for all three COCATS Nuclear Cardiology Training Levels.
- + Weekly educational conference.
- + Daily teaching sessions.
- + Faculty involved in Mayo Clinic CME courses and leaders in national and international cardiology, nuclear cardiology and imaging organizations and societies.

Research

- + Dedicated Nuclear Cardiology database for both cardiac SPECT and PET studies with over 200 publications to date using these databases
- + Quality improvement projects
- + Many prospective investigations involving new SPECT, PET and hybrid technologies
- + A leading laboratory in researching Appropriate Use Criteria

CARDIOVASCULAR CT AND MRI

The practice of computed tomography (CT) at Mayo Clinic has a long and storied history, dating back 40-plus years to 1973 when the first CT scanner in North America was installed at the Mayo Clinic in Rochester.

That tradition of innovation and early adoption of innovative techniques extends to the present day. Our fellowship-trained cardiovascular imaging specialists have access to cutting-edge equipment that is continually updated to include the latest technology and best results to patients.

CT Department of Radiology Resources and Performance

- + 19 total CT scanners, including one dedicated to clinical innovation
- + 9 CT scanners ACR accredited for cardiac imaging
- + 8 dual-source CT scanners (one first generation, five second generation, two third generation)
- + 149,047 CT scans performed in 2014, including 12,242 cardiovascular scans

MRI is an area of tremendous growth in medical imaging and cardiovascular MRI is a big part of that growth. Since the first cardiac MRI was performed at Mayo Clinic in 1983, this modality has grown to include 11 subspecialty trained imagers who have access to four clinical MRI scanners (both 1.5 and 3.0 T (Tesla) magnets that will soon grow to a suite of six, and perform in excess of 2,000 examinations per year.

This is an active and innovative practice which offers a broad range of services, including perfusion, viability and stress imaging as well as evaluation of nonischemic cardiomyopathies and congenital heart disease. All our imagers are trained in multimodality imaging and are committed to matching the appropriate examination to the patient based on individual indication.

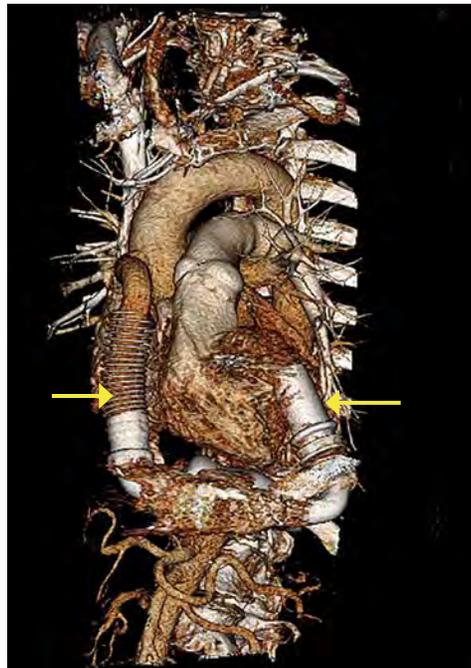


Figure 1. At left, a 3D volume-rendered image from an ECG-gated cardiac CT in a patient with a Heart Mate II Left Ventricular Assist Device (LVAD). Arrows show the outflow (left arrow) and inflow (right) cannulas.

Figure 2. In the CT above from the same patient, a thick slab has been taken through the volume-rendered image showing the left and right ventricle in short axis, the LVAD pump, a portion of the outflow cannula and the inflow cannula.

MRI Department of Radiology Resources and 2014 Performance

- + 29 clinical MRI scanners, one PET/MR scanner, two research MRI scanners
- + 75,060 total MRI scans performed
- + 2,162 cardiac MRI scans performed



RESEARCH + INNOVATION

- + *Our Approach to Heart Research*
- + *Regenerative Medicine*
- + *Quality Initiatives in Cardiology*

OUR APPROACH TO HEART RESEARCH

Patient-Centered Innovation

The goal of all cardiovascular research at Mayo Clinic is to innovate solutions that resolve patient problems and relieve human suffering. We never stray from our founding focus: That our first responsibility is to our patients who have entrusted us with their well-being.

Labs to lives

From molecular pathways to clinical trials, we continually seek new medical knowledge and ways to rapidly and responsibly validate and apply it. Indeed, part of the Mayo Clinic intellectual legacy is our ability to integrate and translate our research discoveries so they can impact real lives in as close to real time as possible.

Mentors and leadership

Current research projects involve collaborations between Mayo Clinic clinicians and scientists, as well as with academic and industry partners around the world.

Mentoring is a key part of our culture of creativity that informs our research mission. We seek to foster the education and mentorship of clinicians and scientists so they may pass on core knowledge, habits of mind, methods of inquiry and, most of all, a talent for forming lasting and deep relationships around research. By these means we hope to develop future leaders of next-generation innovations.

COLLABORATIVE SCHOLARSHIP: Top 10 Most-Cited Papers, 2005-2015, involving Mayo Clinic Cardiology, Cardiovascular Surgery, Pediatric Cardiology

Based on Web of Science database queries through September 21, 2015

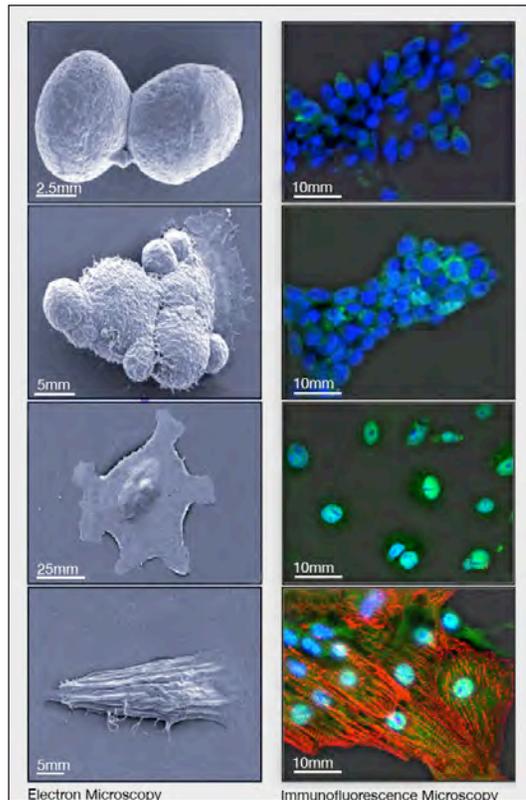
Article	Journal	Year	Citations
1. Trends in prevalence and outcome of heart failure with preserved ejection fraction	<i>New England Journal of Medicine</i>	2006	1,276
2. Secular trends in incidence of atrial fibrillation in Olmsted County, Minnesota, 1980 to 2000, and implications on the projections for future prevalence	<i>Circulation</i>	2006	871
3. Endothelial function: Cardiac events	<i>Circulation</i>	2005	805
4. Burden of valvular heart diseases: A population-based study	<i>The Lancet</i>	2006	729
5. Metabolic syndrome and risk of incident cardiovascular events and death: A systematic review and meta-analysis of longitudinal studies	<i>Journal of the American College of Cardiology</i>	2007	683
6. Association of body weight with total mortality and with cardiovascular events in coronary artery disease: A systematic review of cohort studies	<i>The Lancet</i>	2006	528
7. Left atrial size: Physiological determinants and clinical applications	<i>Journal of the American College of Cardiology</i>	2006	420
8. Quantitative determinants of the outcome of asymptomatic mitral regurgitation.	<i>New England Journal of Medicine</i>	2005	417
9. Compendium of cardiac channel mutations in 541 consecutive unrelated patients referred for long QT syndrome genetic testing	<i>Heart Rhythm</i>	2005	304
10. Intraoperative hyperglycemia and perioperative outcomes in cardiac surgery patients	<i>Mayo Clinic Proceedings</i>	2005	184

REGENERATIVE MEDICINE

Harnessing the biological power to heal

Regenerative medicine is poised to offer solutions for many of today's incurable cardiovascular diseases. Mayo Clinic teams have led the quest for advanced regenerative technologies to address the needs of patients with heart failure.

Promising strategies are now entering pivotal clinical trials, and Mayo Clinic—as a prime health care provider—is at the vanguard of harnessing the promise of regenerative medicine.



Generating cardioreparative stem cells. A Mayo Clinic innovation enables guidance of stem cells (first and second rows) into lineage-specified cardiovascular progenitors (third and fourth rows) seen under electron (left column) or in immunofluorescence (right column) microscopy. Translation of this fundamental knowledge into protocols applicable for patient-derived stem cells has enabled derivation of next generation regenerative products, currently in advanced clinical trials for patients with heart failure post-infarction. *(Credit: Mayo Foundation for Medical Education and Research)*

Highlight on milestone achievement: Stem cells for congenital heart disease

Mayo Clinic's regenerative therapy program is the first in the U.S. to offer Food and Drug Administration-approved stem cell clinical trials for pediatric congenital heart disease.

Researchers at the Todd and Karen Wanek Family Program for Hypoplastic Left Heart Syndrome (HLHS) are pioneering regenerative approaches in infants identified prenatally with HLHS. By storing an infant's umbilical cord at the time of birth, his or her own stem cells are available for infusion into the right ventricular tissue in open heart surgery at four to six months.

Early studies suggest stem cells can aid in the development of an enduring right ventricle and support its function. As a therapy for HLHS, autologous stem cell implantation may help prevent or delay the need for cardiac transplantation.

MAYO CLINIC REGENERATIVE MEDICINE TIMELINE, 2012-2015

2012

- Mayo Clinic launches Center for Regenerative Medicine with dedicated programs in adult, congenital, and vascular and valvular regeneration.

2013

- Mayo Clinic technology, enabling stem cell guidance to achieve cardioreparative potential, successfully tested in patients with heart failure, providing the basis for advanced clinical trials.

2014

- Mayo Clinic chosen as national hub for pivotal clinical trial that tests guided stem cells in patients with heart failure.
- Minnesota Legislature passes the Minnesota Regenerative Medicine Act with dedicated appropriation in support of regenerative medicine build-out across the state of Minnesota.

2015

- Mayo Clinic launches the Advanced Product Incubator, a state-of-the-art platform complementing the Regenerative Medicine Biotrust and Good Manufacturing Practice facilities for manufacture of clinical-grade regenerative products.

QUALITY INITIATIVES IN CARDIOLOGY

Genetic testing to optimize medication decisions

Tailored Antiplatelet Therapy Following PCI (TAILOR-PCI)

ClinicalTrials.gov Identifier: NCT01742117

Up to 30 percent of patients who undergo percutaneous coronary intervention (PCI) angioplasty have a genetic variation in the CYP2C19 liver enzyme that interferes with one of the most widely prescribed heart medications for these patients, clopidogrel (Plavix).

Through the Mayo Clinic-initiated Tailored Antiplatelet Therapy to Lessen Outcomes after Percutaneous Coronary Intervention (TAILOR-PCI) study, researchers are using pharmacogenomics to improve quality of care by optimizing therapy on an individual basis for each patient.

In the TAILOR-PCI study, researchers:

- + Analyze the patient’s CYP2C19 gene to determine the best medication match for patients undergoing coronary angioplasty
- + Are enrolling patients now with a goal of ~6,000 from all Mayo sites and top cardiology centers in the U.S., Canada and South Korea
- + Expect immediate results that may guide antiplatelet medication decisions and affect cardiac catheterization practices
- + Are obtaining data to assess the potential cost impact of gene testing on the health care system
- + Will build a coronary artery disease biobank open to all researchers containing DNA samples from all participants to help further understand risk factors for coronary heart disease

Reducing Readmission Rates of Heart Failure and MI: HEARTS2HOME

“Preventing 30-Day Hospital Readmissions,”

Journal of the American Medical Association Internal Medicine, 2014

Mayo Clinic heart researchers found that 30-day hospital readmissions can be reduced by almost 20 percent when specific efforts are made—such as visits from a traveling nurse to ease the post-discharge transition—according to their review of 47 studies. The finding is important because data estimate that 1 in 5 Medicare beneficiaries are readmitted within 30 days of a hospitalization, at a cost of more than \$26 billion a year.

To reduce cardiac-related readmissions, Mayo Clinic initiated “Hospital Exit and Related Transitions to Home, Office, Medical Facility and End-of-Life Decision” (HEARTS2HOME). It is a multidisciplinary program to encourage communication and streamline post-discharge follow-up for patients with heart failure and myocardial infarction (MI).

HEARTS2HOME:

- + Stresses patient education to help patients and their families learn more about their recovery and master care regimens at home
- + Meshes with experts at Mayo Clinic’s Heart Failure Clinic
- + Calls on Employee and Community Health (ECH) physicians to help manage the patient’s transition from hospital to home
- + Arranges for nurse visits at the time of hospital discharge and in-home visits

Focus on GRANTS AND TRIALS

Advancing patient care by accelerating scientific discovery starts in laboratories closely aligned with clinicians and faculty across disciplines. Winning funding through a variety of grants is central to our scientific success, as is translating laboratory findings through clinical trials to move them into clinical use.

Extramural Grant Summary

GRANT	2011	2012	2013	2014
NIH R (Research Programs)	24	29	25	22
NIH P (Program Projects & Centers)	15	9	9	7
NIH U (Cooperative Agreements)	3	3	3	4
NIH K (Career Development)	1	1	2	3
NIH T (Training)	1	1	1	1
Other Federal	3	2	1	0
Subawards	35	29	33	33
Foundation	13	14	18	20
Industry	117	111	114	130
TOTALS	211	199	206	220

Clinical Trial Activity

PROGRAM	# Pending	# Enrolling	# Following
Circulatory Failure Program	16	23	5
Heart Rhythm Services	9	12	6
Ischemic Heart Disease Program	9	25	14
Preventive Cardiology Program	4	3	2
Structural Heart Disease Program	6	16	4
Vascular Medicine Program	2	1	0
TOTALS	46	80	31

NOTE: Data retrieved from Intellitrial system.



EDUCATION

- + *Education and Fellowships*
- + *Continuous Professional Development*

EDUCATION AND FELLOWSHIPS

We highly value continual professional growth in all dimensions of learning and, to foster that, provide comprehensive fellowships in cardiovascular medicine in Arizona, Florida and Minnesota.

Outcomes and assets

- + Upon completion, fellows are eligible for the American Board of Internal Medicine’s subspecialty examination in cardiovascular disease.
- + 95 percent pass rate for CV Boards between 2010 and 2014.
- + Educational tracks tailored to meet individual fellow’s goals and needs.
- + Nine subspecialty fellowships.

Clinical Fellowships

Our Cardiovascular Diseases Fellowship began in 1961 in Rochester, Minnesota, and in 1991 in Mayo Clinic Arizona and 2008 at Mayo Clinic Florida.

Key features

- + Our four-year Accreditation Council for Graduate Medical Education (ACGME) Clinical Fellowship begins with two years of core rotations, followed by one year of protected time for research under the mentorship of an experienced leader in the field of cardiovascular research. The fourth year focuses on subspecialty electives, including interventional cardiology, electrophysiology, cardiac imaging, heart failure/transplant, adult congenital heart disease, vascular disorders and other advanced training options.

3 Accredited Advanced Fellowships <i>(Each 12 months long following core training)</i>	3 Unaccredited Advanced Training Areas
Electrophysiology	Valvular Heart Disease
Advanced Heart Failure and Transplant	Echocardiography
Interventional Cardiology	Vascular Medicine

Fellowship and training opportunities

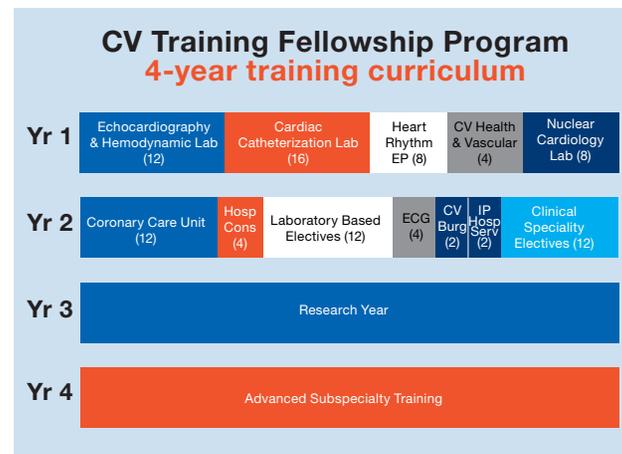
- + 9 clinical fellows accepted each year
- + Both accredited and unaccredited fellowships provide a wide range of training in diagnosis, evaluation and treatment of common and rare cardiovascular diseases and training in all cardiovascular procedures.

Research Fellowships

We foster peer-reviewed, extramurally funded research as well as training, mentoring, and career development in more than 20 specialty areas.

Key features

- + Premiere translational discovery center in the nation. In 2006, Mayo Clinic became one of the first 12 institutions in the country to receive a Clinical and Translational Science Award from the National Institutes of Health (NIH). Now, Mayo Clinic’s Center for Clinical and Translational Science (CCaTS) program is one of the nation’s 60 NIH-funded centers, and a leader focused on streamlining bench-to-bedside discoveries to improve community health.



CV training fellowship curriculum topics, by year

- + 2 research fellows accepted each year.
- + In-depth research training in clinical, basic science, and translational research practices.
- + Broad support within Mayo Clinic for research training and funding.

Clinician-Investigator Training Program

Residents and fellows interested in pursuing a career that includes research within a robust clinical practice can choose either the two- or three-year integrated, comprehensive educational program. Mayo Clinic’s Center for Clinical and Translational Science (CCaTS) program is a leading center of translational expertise.

Cardiovascular fellows generate high publication rate

In a typical year, our cardiovascular fellows publish approximately 60 novel research findings, reviews and editorials in leading medical journals, including:

- + *Circulation*
- + *European Heart Journal*
- + *Heart*
- + *Journal of the American College of Cardiology*
- + *Journal of Clinical Endocrinology and Metabolism*
- + *Journal of Clinical Epidemiology*
- + *Journal of Thoracic and Cardiovascular Surgery*
- + *Journal of the American College of Cardiology: Cardiovascular Intervention*
- + *Journal of the American College of Cardiology: Heart Failure*
- + *The Lancet*
- + *Mayo Clinic Proceedings*
- + *Nature Cell Biology*
- + *PLoS One*

CONTINUOUS PROFESSIONAL DEVELOPMENT

Our Continuing Medical Education portfolio offers unique breadth and depth and is continually revised to help medical professionals fully meet the challenges of 21st-century medicine. In 2014, we offered 38 conferences in major CV specialties and subspecialties taught by leaders in the field, and presented at all major heart conferences.¹

Elements of success

- + 4.65 out of scale of 5.0 overall satisfaction rating for CME courses in 2014.
- + Continually revised and updated topics address the latest developments in diagnostic and treatment approaches.
- + Case-based format, addressing complex and realistic disease scenarios.
- + Accessible through a range of communication technologies. Courses may be viewed live; some available for later viewing.
- + Participants submit live questions by text or email, prompting wider audience engagement and ensuring learners' needs are met while also facilitating the flow of the course.

Accreditation Council for Continuing Medical Education (ACCME) Board Review Courses

Courses are available in all CV areas where certification exists and for Maintenance of Certification (MOC).

Key features

- + State-of-the-art content aligned with key learning objectives of the boards.
- + Topics are geared toward MOC diplomates of American Board of Internal Medicine (ABIM), the American Board of Family Medicine (ABFM) and the American Board of Pediatrics (ABP).

Professional enrichment courses

Courses are available year-round to meet all schedules and most content needs.

Key features

- + Cardiovascular Grand Rounds, where experts in the field discuss key topics in CV disease: <http://medprofvideos.mayoclinic.org/CVgrandrounds>.
- + Cardiology Self-Study program is a new accredited offering to help those who want to stay current with advances in the cardiovascular field or who want to attain CME credit.
- + Piloting emerging new educational programming through iTunes U, YouTube and various apps to facilitate the mobile platform and adult learning theory.

¹ 2014 Cardiology Annual Report

CONNECT WITH US

REFERRALS AND CONSULTATIONS

Mayo Clinic welcomes inquiries and referrals at all our campuses. A request to a specific physician is not required.

ROCHESTER, MINNESOTA



Cardiovascular Diseases: 800-471-1727 (*toll-free*) Fax: 507-266-5278
Cardiovascular Surgery: 866-827-8810 (*toll-free*) Fax: 507-255-7378
Pediatric Cardiology: 507-284-9969 Fax: 507-538-5817

PHOENIX/SCOTTSDALE, ARIZONA



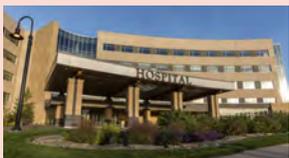
Appointments: 480-301-6539
 866-629-6362 (*toll-free*)
Fax: 480-301-4071
Toll-free from Mexico: 001-800-010-1390

JACKSONVILLE, FLORIDA



Appointments: 904-953-2934
 800-634-1417 (*toll-free*)
After Hours: 904-953-2000
Fax: 904-953-0759

MAYO CLINIC HEALTH SYSTEM



The hospital in Eau Claire, Wisconsin, is the site for open heart surgery within the Mayo Clinic Health System.

Albert Lea, Minnesota 507-379-2151
Austin, Minnesota 507-434-1262
Eau Claire, Wisconsin 715-838-6320
La Crosse, Wisconsin 608-392-9862
Mankato, Minnesota 877-412-7575 (*toll-free*)
Waycross, Georgia 912-284-2460

Mayo Clinic Health System offers heart care in more than 30 communities in Georgia, Iowa, Minnesota and Wisconsin. For information about general heart services, contact its regional centers listed above. For questions about open heart surgery available within the Mayo Clinic Health System contact Eau Claire, Wisconsin.

Twitter

Receive real-time news and thought-leading insights by following @MayoClinicCV

Mayo Clinic on Medscape Cardiology

Mayo joins forces with Medscape Cardiology to bring you the latest perspective on clinical trials, patient care and news: <http://www.medscape.com/partners/mayoclinic>.

Cardiovascular Physician Update E-newsletter

Our bimonthly e-newsletter features news and information about diagnostic and therapeutic techniques in cardiology and cardiovascular surgery: <http://www.mayoclinic.org/medical-professionals/sign-up-email-newsletters>.

Medical Professional Video Center

Watch Grand Rounds lectures and other presentations and videos describing advances in disease and condition treatment, procedures and surgeries: <http://www.mayoclinic.org/medical-professionals/sign-up-email-newsletters/cardiovascular-physician-update-electronic-edition>.

Patient Educational Resources

Many Mayo Clinic-produced educational videos are available on YouTube.





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