Oklahoma Heart Institute

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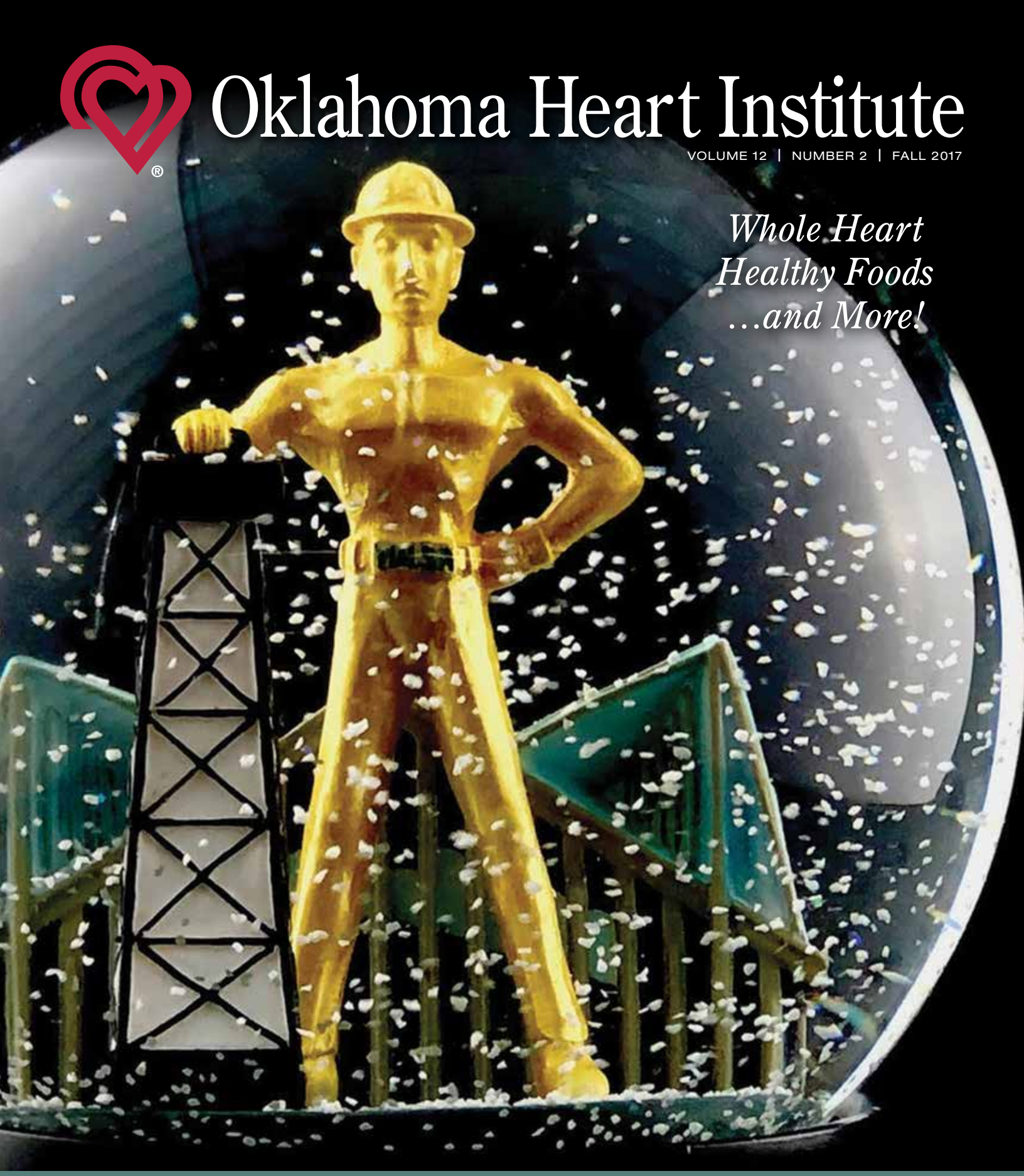

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Alternative Access Transcatheter Aortic Valve Replacement

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Mitral Valve Repair for Degenerative Valve Disease

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Oklahoma Heart Institute
at Utica Physicians Offices
1265 S. Utica Ave., Suite 300, Tulsa, OK 74104
P) 918.592.0999 • F) 918.595.0208

Oklahoma Heart Institute
at Southpointe Physicians Offices
9228 S. Mingo Road, Suite 200, Tulsa, OK 74133
P) 918.592.0999 • F) 918.878.2408

Hillcrest Hospital South
8801 S. 101st E. Ave., Tulsa, OK 74133
P) 918.294.4000

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Elaine Burkhardt at 918.749.2506
newsgroupcom@gmail.com
visit our website at www.oklahomaheart.com

The Oklahoma Heart Institute Magazine is mailed directly to referring physicians and other referring health care professionals in the Tulsa area and is also available in our patient waiting rooms.

features

to our readers

Advances in medicine continue to improve the quality of life for many patients. This issue of the Oklahoma Heart Institute Magazine highlights several different areas where this is true. Dr. Tharakan, from the OHI Division of Cardiothoracic Surgery, discusses the option of mitral valve repair for patients who have severe mitral regurgitation. Dr. Liff, from the Division of Peripheral Vascular Disease, emphasizes how prevention and aggressive care of peripheral artery disease can decrease needs for amputation. Dr. Newnam, from the Sleep Division at OHI, describes the issues related to getting a good night's sleep which can lead to an improved quality of life. Finally, Dr. Muhammad, from the Division of Structural Heart Disease, discusses the major advances in treating structural heart disease with minimally invasive procedures that can be done in a cath lab.

We hope that you enjoy the articles and welcome any comments or suggestions regarding the magazine content.

Sincerely,
Wayne N. Leimbach, Jr., MD
Publisher/Editor, Oklahoma Heart Institute Magazine

ON THE COVER

Commemorated in this new snow globe, the 75-foot tall Golden Driller oilman is the fifth largest statue in the United States.

It was originally built in 1952 by the Mid-Continent Supply Company of Fort Worth for the International Petroleum Exposition and was so popular, they later donated it to the Tulsa Fairgrounds Authority.

An inscription at the base of the Golden Driller reads"The Golden Driller, a symbol of the International Petroleum Exposition. Dedicated to the men of the petroleum industry who by their vision and daring have created from God's abundance a better life for mankind."

The snowglobe is available at Tulsa's Ida Red in Brookside and also in the Brady Arts District.

Alternative Access Transcatheter Aortic Valve Replacement: Transcaval Access

By Kamran I. Muhammad, MD, FACC, FSCAI and Georgianne Tokarchik, APRN-CNS

Aortic stenosis is one of the most common cardiac valvular abnormalities in the United States. It is estimated that aortic stenosis affects approximately 5 of every 10,000 adults, with the prevalence increasing with age. Severe aortic stenosis results in severe symptoms of congestive heart failure (shortness of breath, leg swelling, pulmonary edema), chest pain/angina or syncope (nearly passing out or passing out).

Prompt recognition of the onset of symptoms due to severe aortic stenosis is essential, as mortality dramatically increases after such symptoms develop. Specifically, the 2-year mortality after the onset of symptoms in severe aortic stenosis is 50%, and the 5-year mortality is 80%. As such, prompt evaluation for aortic valve replacement is recommended for patients with severe symptomatic aortic stenosis.

Surgical replacement of the aortic valve results in improvement of symptoms and normalizes survival. However, given the highly invasive nature of open-heart surgery for surgical aortic valve replacement, coupled with the age group and associated co-morbidities of patients with severe aortic stenosis, there remains a large number of patients with severe aortic stenosis that go untreated. Numerous studies over the past decade have shown that at least 40% of patients with severe aortic stenosis never undergo surgical aortic valve replacement.

The 2-year mortality after the onset of symptoms in severe aortic stenosis is 50%, and the 5-year mortality is 80%.

Transcatheter Aortic Valve Replacement

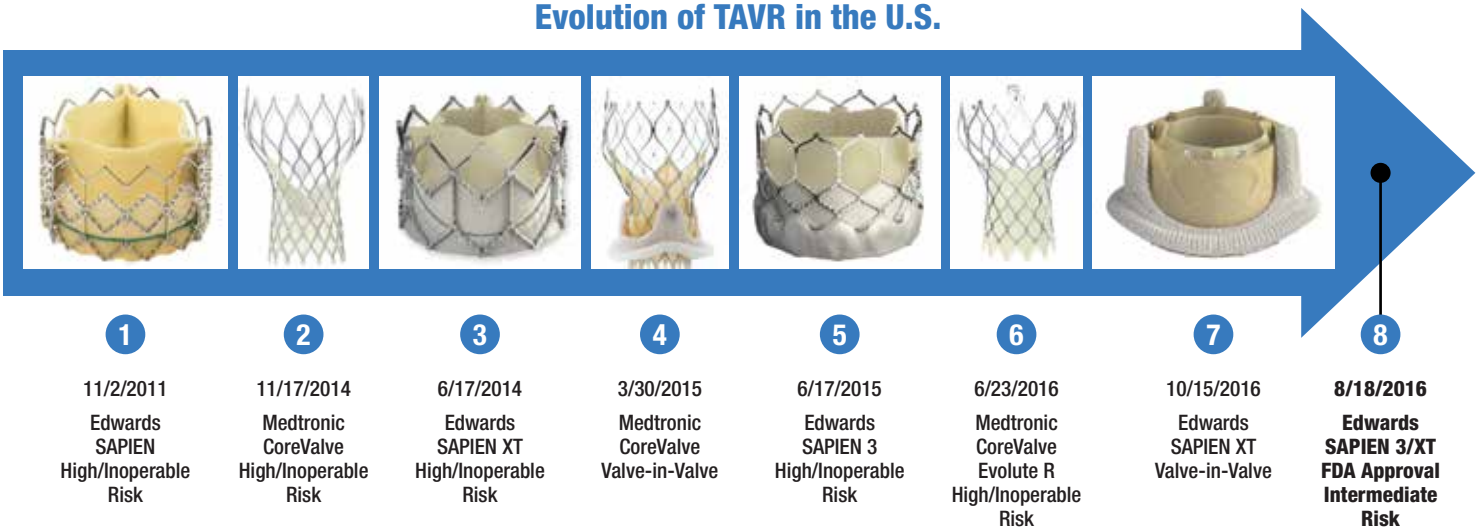
Transcatheter aortic valve replacement (TAVR) has been developed as a minimally invasive approach in patients with severe symptomatic aortic stenosis as an alternative to surgical aortic valve replacement. TAVR is an established procedure; over 250,000 procedures have been performed in over 65 countries across the world to date and more than 100,000 procedures have been performed in the US over the past 5 years. The first TAVR procedure was performed in 2002 by a French cardiologist, Dr. Alain Cribier.

TAVR with the Edwards SAPIEN (1st generation) bovine balloon-expandable transcatheter aortic valve was approved in the United States on November 2, 2011. The Food and Drug Administration (FDA) approved the currently used 3rd generation Edwards SAPIEN 3 transcatheter heart valve (THV) on June 15, 2015. In addition, the 2nd generation Medtronic CoreValve Evolute R porcine self-expanding transcatheter aortic valve received FDA approval on June 23, 2015 (Figure 1).

The majority of TAVR cases (>80%) can be performed from a transfemoral approach, percutaneously (without surgery) through the femoral (groin) artery, similar in concept to a cardiac catheterization procedure. However, transfemoral access is not an option in all patients due to diseased or small femoral and pelvic arteries making it unsafe to pass the TAVR delivery sheath without high risk of inju-

Figure 1

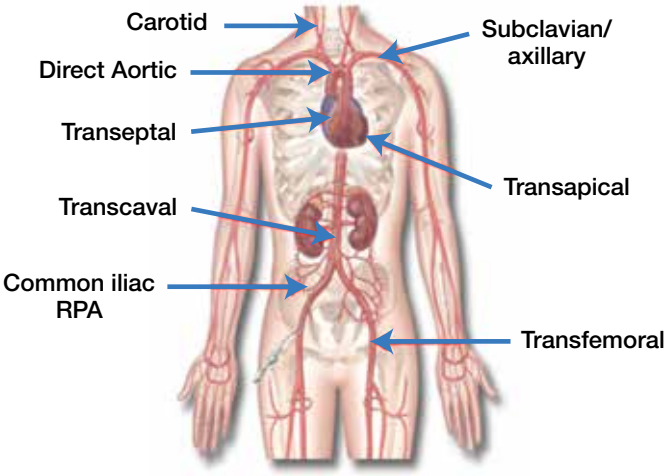
Evolution of TAVR in the U.S.



ry. This has led to the development of alternative access approaches for delivery of the transcatheter heart valve.

Despite the development of a number of alternative access approaches for TAVR (Figure 2), the majority of these approaches are more invasive than transfemoral TAVR and many of them require some type of surgery, usually in the chest. This increases the risk for patients compared to transfemoral TAVR, which requires no surgery and no instrumentation of the chest cavity. Given the generally high-risk nature of the patients being treated with a non-femoral approach, there has been a great deal of interest in developing an alternative percutaneous non-surgical approach for TAVR. Transcaval TAVR has been developed with these considerations and goals in mind.

Figure 2



Transcaval Access TAVR

Transcaval access TAVR was developed for patients who are not candidates for traditional transfemoral TAVR due to small pelvic arteries and in whom traditional surgical alternative access was felt to be high-risk.

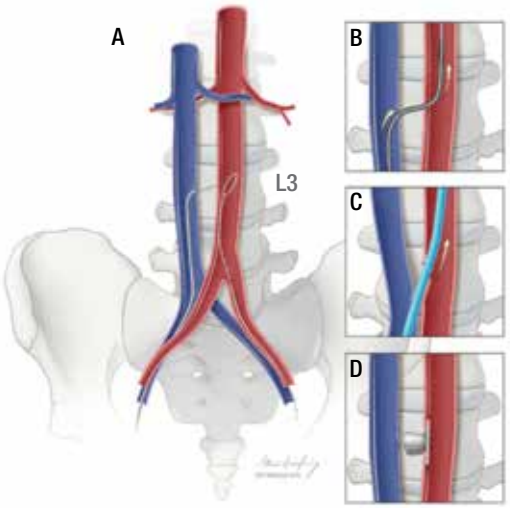
Transcaval access TAVR refers to access into the abdominal aorta (main artery in the abdomen) from the femoral vein through the inferior vena cava (main vein in abdomen) (Figure 3a). This technique is fully percutaneous (no surgery needed).

This technique relies on the principle that the deep veins of the body are much larger and more distensible than the arteries. However, the aortic valve is on the arterial side of the circulation and there is no natural connection between the venous and arterial circulations to allow for delivery and deployment of a replacement aortic valve from the venous side. Therefore, with transcaval access a connection from the venous system to the arterial system is carefully planned and created in the abdomen between the main vein (inferior vena cava) and main artery (aorta) to allow for delivery of the new aortic valve. This takes advantage of the large and distensible veins in the abdomen and pelvis to deliver the valve to the aorta, thus bypassing the small and diseased arteries of the pelvis. Following completion of the TAVR procedure, the arterial component of the venous-arterial connection in the abdomen is closed to ensure there is no bleeding from the high-pressure aorta into the abdominal space.

The physiology of transcaval access provides insight as to why this approach is feasible. Studies have demonstrated that the opening created in the vena cava during the procedure serves to decompress aortic bleeding during transcaval access and closure. The surrounding retroperitoneal (abdominal) space pressure exceeds the venous pressure and causes blood to return from the aorta into the circulation through the vena cava. The vena cava has the lowest pressure in the abdomen and acts as a natural sink or sump for blood to flow from the aorta to the inferior vena cava (Figure 4).

Figure 3

Transcaval Access Technique for TAVR



Greenbaum, A.B. et al. J Am Coll Cardiol. 2017;69(5):511-21

A pre-procedural CT scan is used to determine an appropriate preselected target site for crossing from the inferior vena cava into the abdominal aorta. A crossing catheter is placed in the inferior vena cava and a snare (wire loop) at the predetermined crossing site is placed in the aorta. Next an energized wire is passed from the vena cava across to the aorta and captured by the snare, thereby creating the caval-aortic tract (Figure 3b). Next, through this caval-aortic tract, the sheath (large tube) used to deliver the heart valve is then advanced from the vein into the aorta (Figure 3c). Once in the aorta, the patient's pelvic arteries that were not adequate for transfemoral access have been bypassed and transcatheter aortic valve replacement is performed as usual.

After successful placement of the transcatheter aortic valve, the caval-aortic tract is then closed using a nitinol occluder device (plug) (Figure 3d). The occluder device is used to close the opening in the side wall of the aorta that was created for this procedure, and is done as the large sheath is removed from the aorta. The closure of the aorta is then evaluated with angiography to ensure there is no bleeding from the aorta into the abdomen. Simple measures can then be utilized to treat any significant bleeding into the abdominal space from the aorta.

Following transcaval TAVR, patients are monitored in the hospital and generally are discharged within 1-2 days of the procedure, similar to transfemoral TAVR. This contrasts to other alternative access TAVR approaches which generally result in the patient remaining in the hospital for a longer period of time and experiencing more pain and discomfort

Figure 4

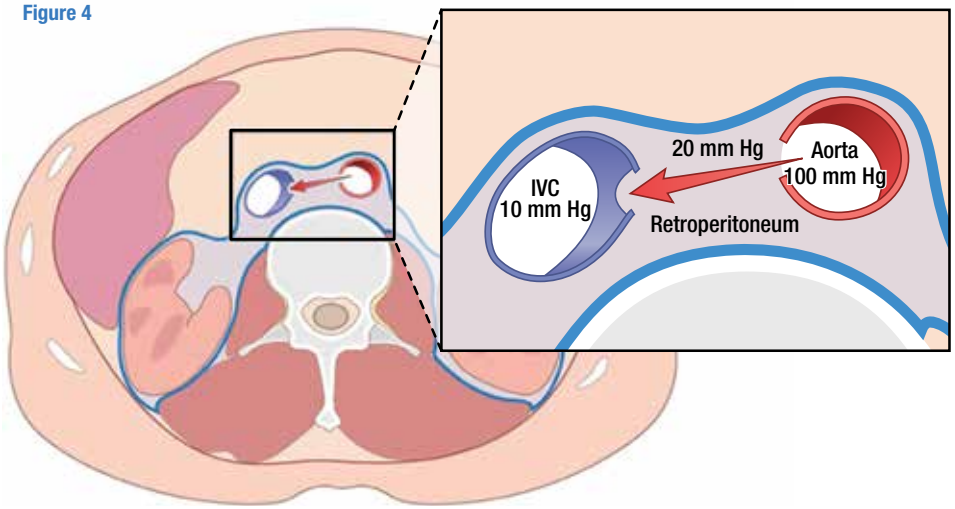


Figure 5

A. CT-based plan

B. Aortogram / cavagram

C. Electrified wire crossing into aortic snare

D. TAVR delivery sheath from femoral vein into aorta

E. Final closure of aorto-caval tract with ADO-1 plug

following the procedure, all contributing to a slower recovery as compared with transcaval TAVR.

Transcaval Access Research

Initial animal studies performed at the U.S. National Institutes of Health demonstrated that transcaval access was feasible. The technique was then performed in humans and again the feasibility and safety of the technique was demonstrated in a series of patients.

The transcaval approach was subsequently systematically assessed in a multi-center prospective study of 100 patients — Transcaval Access for Transcatheter Aortic Valve Replacement in People with No Good Options for Aortic Access. The study demonstrated that transcaval access was successful in 99% of the patient's enrolled in the trial. Additionally, transcaval access for TAVR was found to be a safe and effective option for patients who otherwise have limited options. The study was published in the Journal of the American College of Cardiology in October 2016. Oklahoma Heart Institute was one of the top three medical centers to enroll patients in the trial.

Case Study of Transcaval TAVR at Oklahoma Heart Institute

This is an 80-year-old male patient at OHI with multiple medical problems including coronary artery disease with previous coronary artery bypass grafting surgery in 2012, history of permanent pacemaker implantation, and severe symptomatic aortic stenosis with disabling heart failure symptoms. The patient was evaluated by the cardiac surgery team and felt to be a high risk for surgery to replace his aortic valve.

CT scanning demonstrated his leg and pelvic arteries to be too small for transfemoral access due to severe peripheral arterial disease. CT scanning also demonstrated that he was a good candidate for transcaval TAVR (Figure 5a). In the opinion of the OHI TAVR heart team, transcaval TAVR was felt to be his best option — allowing for a minimally invasive, non-surgical approach to replace his aortic valve.

The patient's procedure was performed in the hybrid cardiac catheterization laboratory (Figure 5b-e). Following successful percutaneous transcaval access via the technique described above, successful TAVR with a 26 mm Edwards Sapien 3 transcatheter heart valve was performed. Closure of the caval-aortic tract was performed using an Amplatzer Duct Occluder-1 (ADO-1) device (Figure 5e). The patient was monitored in the cardiovascular step down unit following the procedure and was out of bed later the same day. The patient did well throughout his hospitalization and was discharged home on day two following his procedure. A CT scan of the abdomen the day following the procedure showed no evidence of bleeding and complete closure of the caval-aortic tract with the occluder device (Figure 5e).

The patient is now greater than one year out following transcaval TAVR and is doing extremely well with no congestive heart failure symptoms and normal function of his aortic valve.

OHI Experience with Transcaval TAVR

Oklahoma Heart Institute was the first program in Tulsa and region to offer TAVR, and we remain the most experienced program in the region with excellent clinical outcomes. Oklahoma Heart Institute serves as a referral center for patients needing TAVR and other advanced valve procedures from adjacent states. We often evaluate and treat patients with very high-risk conditions who have been turned down at other cardiovascular centers. Thus far this year, we have performed >100 TAVR procedures.

To date, 450 transcaval TAVR procedures have been performed worldwide and Oklahoma Heart Institute ranks as the third highest site by volume for transcaval TAVR in the world. Oklahoma Heart Institute physicians serve as national proctors for transcaval access TAVR — traveling throughout the United States to teach and proctor other physicians on performing the procedure.

By remaining at the cutting edge of technology and advanced techniques and with a continual commitment to bring world class care home to our patients, we will continue our mission as the leading cardiovascular institute in the region.

For more information visit: www.oklahomaheart.com/TAVR or call 918-592-0999 and ask for an appointment at the TAVR clinic.

Dr. Muhammad is a subspecialist in interventional cardiology. In addition to expertise in traditional areas of interventional cardiology, such as coronary intervention (angioplasty, stent placement, atherectomy, intravascular imaging) and peripheral vascular and carotid artery intervention, Dr. Muhammad has a special interest and expertise in interventional therapies for structural and valvular heart disease including the percutaneous non-surgical replacement and repair of heart valves - TAVR and MitraClip. He currently serves as the Director of the Structural Heart Disease Program at OHI.

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OklahomaHeart.com

Are you getting enough sleep?

By Michael Newnam, MD

There are several basic needs that all people share. We must eat, we must drink and we must sleep. Sleep is important for recovery and rejuvenation of our bodies and our minds. We need sleep to have a healthy immune system, to recover from physical injury and normal wear and tear on our bodies. We also need sleep to learn effectively and consolidate memory. Without proper sleep, our bodies, minds and emotions pay a heavy price. Unfortunately, as society has made technological breakthroughs like artificial light, televisions, and cell phones, average sleep times have plummeted. The average amount of sleep was 7.9 hours/night in 1942. The average American now gets an average of 6.8 hours of sleep. This means that the average American's sleep has decreased by more than an hour.

The National Sleep Foundation recently published guidelines on recommended amounts of sleep. These recommendations are based on all the current research related to necessary sleep for optimal physical and mental health. They concluded that for adults, 7-9 hours of sleep is ideal. For senior adults the recommendation is from 7-8 hours of sleep (Figure 1).

Why can't we sleep? Insomnia is the most common sleep disorder and has become rampant in our busy and stressed society. It is believed that insomnia is caused by a hyperarousal state in the brain. Many people with longstanding insomnia will say that they "can't turn their brain off." People will often describe feeling tired, but when they attempt to lay in bed and go to sleep, their minds are active and they are unable to sleep. Interestingly, when brain imaging is done on patients with longstanding insomnia, their brains appear to be more active even during sleep than someone without insomnia. This fact gives evidence to the theory that chronic insomnia involves an overly active brain that won't turn off.

There are two basic types of chronic insomnia, sleep onset insomnia and sleep maintenance insomnia. Some people have trouble getting to sleep (onset insomnia) and other have no trouble initially getting to sleep but they wake up during the night and struggle to return to sleep (maintenance insomnia). Over time if a person fails to sleep well, it actually produces anxiety and dysfunctional beliefs about sleep. This can create a long lasting pattern of poor sleep.

There are many conditions that can contribute to insomnia

Figure 1

National Sleep Foundation – Recommended Sleep
Hours of Sleep

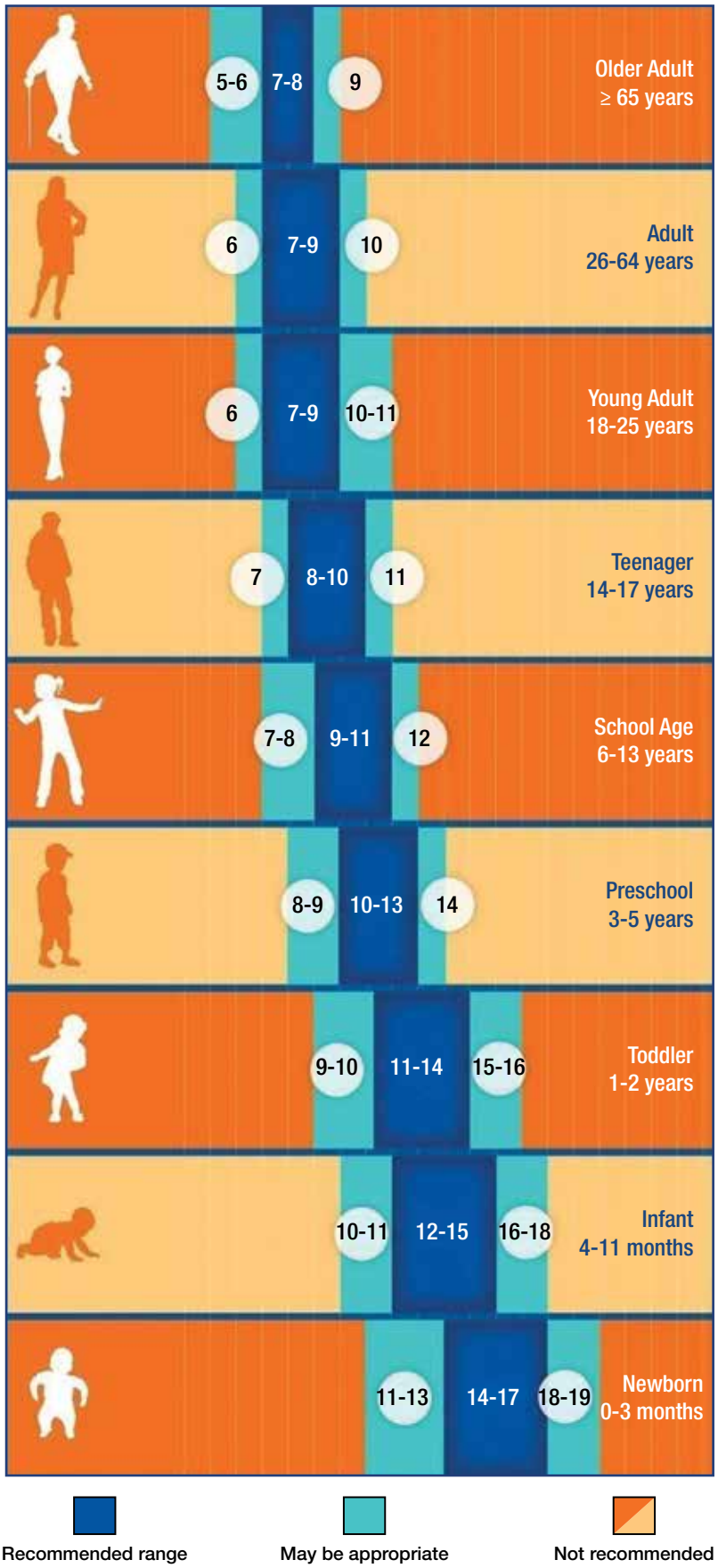


Figure 2

Sleep Hygiene

www.nosleeplessnights.com

including pain, anxiety, depression, restless leg syndrome, sleep apnea, prostate issues and some medications including caffeine. It is important to properly identify any underlying medical conditions that are contributing to insomnia. Treatment of the medical conditions may help to improve sleep.

Although medications play a role in the treatment of insomnia, it's important to take steps to improve sleep naturally. It is critical to establish good sleep habits and create a peaceful environment to allow for the best chance of sleeping well (Figure 2). It is important to get physical exercise, have a bedtime routine that includes low light and relaxation, and avoiding caffeine and heavy meals in the evening. It's also important to have a comfortable bed and comfortable temperature with a dark room to best facilitate sleep. If you can't get to sleep within 15 to 20 minutes, then get up and go to another room and read or listen to relaxing music until you are very tired and ready to go back to bed. Many people just toss and turn in bed frustrated for hours until they finally go to sleep. This behavior makes the bed a very stressful place and makes it less likely you will be able to successfully sleep.

In addition to following good sleep hygiene, cognitive behavioral therapy (CBT) has been used with good success in the treatment of chronic insomnia. CBT for insomnia is a program usually led by a therapist or psychologist. The goal of CBT for insomnia is to reveal and deal with the dysfunctional beliefs and behaviors that have developed in an individual with chronic insomnia. This course of treatment has a good chance of success and has even proven superior to sleep medication in some studies.

If medication is appropriate, then both over the counter (OTC) and prescription medications are available. Melatonin is a natural supplement that increases levels of the hormone melatonin that causes drowsiness. It is generally safe and effective. Many of the OTC sleep aids have antihistamines like Benadryl (Diphenhydramine) in them, which cause drowsiness.

There are several prescription sleep aids available. These can be effective for treating insomnia but they also have potential risks and side effects. It is important to discuss prescription medications for sleep with your doctor and make sure that there is full understanding of the side effects and potential risks with a sleep aid.

With an understanding of good sleep behaviors and prudent use of medications, insomnia can often be improved. It is important to make sure that a full sleep evaluation is done to ensure that the underlying issues contributing to poor sleep are uncovered. If specific conditions like sleep apnea or restless leg syndrome are identified and treated then sleep should be improved. Sometimes a sleep study is ordered as part of the evaluation process, to aid in understanding what other sleep disorders are contributing to the insomnia.

Medical science is beginning to unlock the complex mechanism that controls normal sleep. Unfortunately, 1 in 3 people deal with insomnia and it adversely impacts the quality of their lives. Implementing good sleep hygiene can improve your sleep. If these steps alone do not solve the problem, then it's important to talk with your doctor and get a sleep evaluation. It's important to treat any underlying medical causes of the insomnia. Cognitive behavioral therapy for insomnia is a safe and effective treatment. If medications are needed, it's important to take these under the direction of a physician. Medications can be helpful but do carry risks and can be habit forming. Hopefully we are able to reverse the trend of insufficient sleep and get the 7-9 hours of sleep we need to live healthy and productive lives.

Dr. Newnam is a specialist in the diagnosis and treatment of sleep disorders. He is Director of Sleep Medicine at Hillcrest Medical Center, Bailey Medical Center and Hillcrest Hospital Cushing.

Together We Can Prevent Amputations

By David A. Liff, MD

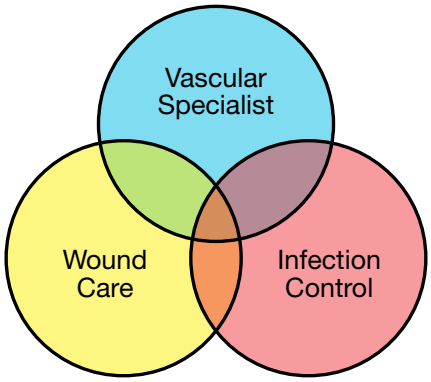
The leading cause of leg amputations is poor circulation, or peripheral artery disease. Peripheral artery disease is common, affecting between 8-12 million Americans. Certain groups of patients are at particularly high risk for peripheral artery disease, including patients with diabetes, kidney disease, and a history of smoking. While most of these patients will be asymptomatic or experience only limitations with exertion, some patients will progress to what is termed critical limb ischemia. Critical limb ischemia means that the patient is at immediate risk for having their leg amputated.

The symptoms and signs of critical limb ischemia are seen in the feet, the endpoint for all lower extremity circulation. Patients may notice discoloration of their feet or that they are cold. As blockages in the legs worsen and blood flow decreases, the muscles and skin in the feet are unable to get adequate nutrients. Eventually, the feet become painful at rest and develop ulcers, often on the toes, that signify an inability to get enough blood to keep the skin and muscle alive. These are the patients who are at risk for amputations, and there are nearly 150,000 new cases of critical limb ischemia in the US annually.

There are nearly 150,000 new cases of critical limb ischemia in the US annually.

The incidence of major amputations (above and below the knee) have decreased by 21% in the Medicare and Medicaid populations over the last decade; however, this success has not been realized uniformly around the country. In certain regions, the rate of amputation is significantly higher, and care for patients at risk for amputations is significantly worse. Here in Oklahoma, people are more likely to get an amputation than those living elsewhere in the United States, and here at Oklahoma Heart Institute, we are aiming to change this dynamic.

Multi-disciplinary Team



Preventing amputations requires the coordinated efforts of various specialties. We call this the multi-disciplinary approach. Experts in wound care, podiatry, infectious disease, and vascular medicine work together to help prevent limb loss in patients with critical limb ischemia. The multi-disciplinary team focuses on three fundamental needs to help heal an ulcer and prevent amputation:

- Wound care
- Revascularization
- Treat infection

Wound care physicians are experts not only in the healing of wounds, but in the prevention of future wounds. The typical wound is the result of a chronic repetitive stress on an area of the foot, perhaps due to something as benign as ill-fitting shoes. Once the protective outer layer of skin, called the dermis, has become compromised, poor underlying blood flow due to arterial blockages prevents the wound from healing. The longer the dermal layer is compromised, the more likely the wound is to become infected. Wound care specialists use a variety of techniques, including removal of dead tissue and application of skin promoting dressings to help heal wounds. Furthermore, as experts in the biomechanics of the foot, they can choose orthotic devices that can address areas on the foot subject to chronic repetitive stresses and thus avoid future wound formation.

Vascular specialists at Oklahoma Heart Institute are experts at restoring blood flow to threatened limbs. Without better blood flow, a wound in the foot is very unlikely to heal on its own despite excellent wound care. Fortunately, we are able to improve the blood flow in over 90% of patients and prevent major amputations. Nationally, the decrease in major amputations rates that we have seen in the last decade have strongly correlated with the increase in procedures to restore blood flow. This correlation is evidence that getting more people referred to a vascular specialist is the cornerstone of preventing amputations.

Vascular specialists and wound care physicians are essential components of a successful amputation prevention team, but various other specialists are necessary to achieve good outcomes. When wounds become infected, infectious disease specialists help guide antibiotic therapy to ensure proper recovery. Endocrinologists can help manage diabetic care; nutritionists are available to suggest a diet that contributes to wound healing; and prosthetists can help provide the right prosthetic device that allows for a patient to return to maximal function and prevent future wounds.

It has been estimated that between 50-85% of all amputations are avoidable with a multi-disciplinary approach. Yet, the majority of patients who ultimately undergo an amputation don't get referred for a chance at improving blood flow before a limb is permanently removed. At the Oklahoma Heart Institute, we are bringing the appropriate specialists together in a coordinated fashion to provide state of the art treatment in a timely and convenient manner to prevent amputations. If you have any questions or need a referral, please call the Oklahoma Heart Institute Vascular Center for more information or an appointment.

David A. Liff is an interventional cardiologist who specializes in peripheral vascular disease as well as coronary interventional disease.

Oklahoma Heart Institute

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Oklahoma Heart Institute Hospital
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Tulsa, OK 74104
P) 918.574.9000

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1265 S. Utica Avenue
Tulsa, OK 74104
P) 918.592.0999 • F) 918.595.0208

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9228 S. Mingo Road
Tulsa, OK 74133
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Oklahoma Heart Institute At Hillcrest Hospital South
8801 S. 101st E. Avenue
Tulsa, OK 74133
P) 918.592.0999

THE DOCTORS OF OKLAHOMA HEART INSTITUTE

Wayne N. Leimbach, Jr., MD, FACC, FACP, FSCAI, FCCP, FAHA

Dr. Leimbach is a specialist in interventional and structural cardiology, including cardiac catheterization, coronary angioplasty, stents, atherectomy, laser, intravascular ultrasound imaging, and direct PTCA/stents for acute myocardial infarction. He also specializes in percutaneous closure of PFOs, ASDs, PDAs and percutaneous valve replacement or repair procedures such as TAVR and MitraClip. He is Director of the Cardiac and Interventional Laboratories at Oklahoma Heart Institute Hospital and also is Past Chief of Cardiology. Dr. Leimbach is Co-Founder of the Lipid and Wellness Clinic at Oklahoma Heart Institute. He is Director of the James D. Harvey Center for Cardiovascular Research at Hillcrest Medical Center, as well as Director of the Oklahoma Heart Research and Education Foundation. He also serves as Clinical Associate Professor of Medicine at the University of Oklahoma College of Medicine-Tulsa. Dr. Leimbach completed a Clinical Cardiology Fellowship and a Research Fellowship at the University of Iowa Hospitals and Clinics. He also completed his Internal Medicine Internship and Residency Programs at Iowa, where he was selected Chief Resident in Medicine. He received his medical degree from Northwestern University in Chicago and his Bachelor of Science degree from the University of Michigan.

Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

Robert C. Sonnenschein, MD, FACC, ASE, RVT, RPVI

Dr. Sonnenschein specializes in echocardiography and noninvasive peripheral vascular imaging. He is Director of Echocardiography at Hillcrest Hospital South and past Director of Peripheral Vascular Ultrasound Imaging at Hillcrest Medical Center and Oklahoma Heart Institute and serves as Clinical Associate Professor of Medicine at the University of Oklahoma College of Medicine – Tulsa. He completed his Cardiology Fellowship at the State University of New York Upstate Medical Center in Syracuse, where he also completed his Internal Medicine Internship and Residency programs. Dr. Sonnenschein received his medical degree from Rush Medical College in Chicago and his Bachelor of Arts degree from the University of Pennsylvania.

Board certified in Internal Medicine, Cardiovascular Disease, and Adult Echocardiography Registered Vascular Technologist

James J. Nemec, MD, FACC

Dr. Nemec is a specialist in echocardiography, stress echocardiography and nuclear cardiology. He serves as Director of Nuclear Cardiology for Oklahoma Heart Institute. Dr. Nemec has served as Assistant Professor of Internal Medicine, Division of Cardiology, at Creighton University and as Assistant Professor, Department of Radiology, also at Creighton University. He completed his Clinical Cardiology Fellowship at the Cleveland Clinic Foundation and his Internal Medicine Internship and Residency at Creighton University. Dr. Nemec also completed a year of training in pathology at the University of Missouri, Columbia, MO. He received his medical degree from Creighton University, where he also received his Bachelor of Arts degree.

Board certified in Internal Medicine, Cardiovascular Disease and Nuclear Cardiology

Gregory D. Johnsen, MD, FACC, FSCAI

Dr. Johnsen is an interventional cardiologist with expertise in cardiac catheterization, angioplasty and related interventional procedures, such as stents and atherectomy. He is Director of Cardiac Rehabilitation at Hillcrest Medical Center and Director of the Hillcrest Exercise and Lifestyle Programs. He completed his Clinical Cardiology Fellowship at the University of Oklahoma – Oklahoma City, where he then finished an extra year of dedicated training in interventional cardiology. He completed his Internal Medicine Internship and Residency training at the University of Oklahoma – Oklahoma City, where he also received his medical degree. Dr. Johnsen received his Bachelor of Science degree from Oklahoma State University.

Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

Alan M. Kaneshige, MD, FACC, FASE, RPVI

Dr. Kaneshige is a noninvasive cardiologist with expertise in adult echocardiography, stress echocardiography and transesophageal echocardiography. He is Director of Congestive Heart Failure at Oklahoma Heart Institute and Past Chief of Cardiology at Hillcrest Medical Center. Dr. Kaneshige completed his Internal Medicine Internship and Residency at Creighton University School of Medicine, where he also received his medical degree. He received a Bachelor of Science in chemistry at Creighton University. Dr. Kaneshige completed his Clinical Cardiology fellowship at Creighton, where he also served as Chief Cardiology Fellow for two years. He completed an additional Cardiac Ultrasound Fellowship at the Mayo Clinic in Rochester. Dr. Kaneshige served as Assistant Professor of Medicine at Creighton University School of Medicine, where he was Director of the noninvasive Cardiovascular Imaging and Hemodynamic Laboratory.

Board certified in Internal Medicine, Cardiovascular Disease, Adult and Transesophogeal Echocardiography

Edward T. Martin, MS, MD, FACC, FACP, FAHA

Dr. Martin is a noninvasive cardiologist with subspecialty expertise in noninvasive imaging. He is Director of Cardiovascular Magnetic Resonance Imaging at Oklahoma Heart Institute and Hillcrest Medical Center. In addition, he is a Clinical Associate Professor of Medicine at the University of Oklahoma College of Medicine – Tulsa. Dr. Martin has specialty training in Nuclear Medicine, as well as additional training dedicated to Cardiovascular Magnetic Resonance Imaging. He completed his Cardiology Fellowship at the University of Alabama and Internal Medicine Internship/Residency training at Temple University Hospital in Philadelphia. He received his medical degree from the Medical College of Ohio. Dr. Martin completed his Master of Science degree in mechanical engineering at the University of Cincinnati and his Bachelor of Science degree in physics at Xavier University. Dr. Martin is a founding member of the Society of Cardiovascular Magnetic Resonance and is a past editorial board member of the Journal of Cardiovascular Magnetic Resonance. Dr. Martin has also been actively involved with the American College of Cardiology (ACC) on a national level participating on numerous committees, writing groups and leadership positions. He is the current ACC Governor of the State of Oklahoma. He is also a 2 time past President of the Board of Directors of Tulsa Metropolitan Division of the American Heart Association and past President of the Intersocietal Commission for the Accreditation of Magnetic Resonance Laboratories (ICAMRL). Locally, he is the current Director of Cardiovascular MRI at OHI and the current Vice Chief of Staff at Hillcrest Hospital South.

Board certified in Internal Medicine and Cardiovascular Disease

Roger D. Des Prez, MD, FACC

Dr. Des Prez is a noninvasive cardiologist with specialty expertise in echocardiography, nuclear cardiology and cardiac computed tomography. He is Director of Cardiac Computed Tomography Services of the Cardiology Department at Bailey Medical Center. Dr. Des Prez received his medical degree and Bachelor of Arts degree from Vanderbilt University. He completed his Residency in Internal Medicine and Pediatrics at University Hospital of Cleveland. Dr. Des Prez practiced for six years as an internist with the Indian Health Services in Gallup, NM. He returned to Vanderbilt University as a member of the Internal Medicine Faculty, at which time he also completed his cardiology training.

Board certified in Internal Medicine, Cardiovascular Disease, Echocardiography, Pediatrics and Nuclear Cardiology

Christian S. Hanson, DO, FACE

Dr. Hanson is a specialist in Endocrinology, Metabolism and Hypertension at Oklahoma Heart Institute with expertise in diabetes, lipids and hypertension. He also serves as Clinical Associate Professor of Medicine in the College of Osteopathic Medicine – Oklahoma State University. He completed a Fellowship in Endocrinology, Metabolism and Hypertension at the University of Oklahoma in Oklahoma City. Dr. Hanson's Internal Medicine Residency and Rotating Internship were completed at Tulsa Regional Medical Center. He received his medical degree from Oklahoma State University and his Bachelor of Science degree from Northeastern Oklahoma State University in Tahlequah.

Board certified in Internal Medicine, Endocrinology and Metabolic Diseases

David A. Sandler, MD, FACC, FHRS

Dr. Sandler is a cardiologist with subspecialty expertise in electrophysiology, complex ablation, and atrial fibrillation management. Dr. Sandler is Director of Electrophysiology at Oklahoma Heart Institute Hospital. He completed his Cardiac Electrophysiology Fellowship and his Cardiovascular Medicine Fellowship at New York University Medical Center, New York, NY. Dr. Sandler performed his Internal Medicine Internship and Residency at Mount Sinai Medical Center, New York, NY. He earned his medical degree from Georgetown University School of Medicine in Washington, DC. Dr. Sandler received his Bachelor of Arts degree at the University of Pennsylvania in Philadelphia.

Board certified in Internal Medicine, Cardiovascular Disease and Cardiac Electrophysiology

Raj H. Chandwaney, MD, FACC, FSCAI, FSVM

Dr. Chandwaney is an interventional cardiologist with expertise in cardiac catheterization, coronary angioplasty and related interventional procedures such as coronary stents, atherectomy, intravascular ultrasound and peripheral vascular interventional procedures. Dr. Chandwaney is Chief of Cardiology and Director of the Chest Pain Center and Cardiology Telemetry Unit at Oklahoma Heart Institute Hospital. He completed his Clinical Cardiology Fellowship at Northwestern University Medical School in Chicago, IL., where he also completed an Interventional Cardiology Fellowship. Dr. Chandwaney's Internal Medicine Internship and Residency were performed at Baylor College of Medicine in Houston, TX. He received his medical degree from the University of Illinois at Chicago. Dr. Chandwaney completed his Master of Science degree at the University of Illinois at Urbana-Champaign, where he also received his Bachelor of Science degree.

Board certified in Internal Medicine, Cardiovascular Disease, Interventional Cardiology and Endovascular Medicine

D. Erik Aspenson, MD, FACE, FACP

Dr. Aspenson is a subspecialist in Endocrinology, Metabolism and Hypertension at Oklahoma Heart Institute, with expertise in diabetes, lipids, hypertension and thyroid diseases. He completed a fellowship in Endocrinology at Wilford Hall Medical Center, Lackland AFB, Texas. Dr. Aspenson's Internal Medicine Internship and Residency were completed at David Grant Medical Center, Travis AFB, California where he served as Chief Resident. He received his medical degree from the University of Oklahoma and his Bachelor of Science degree at Oklahoma State University.

Board certified in Internal Medicine, Endocrinology and Metabolic Diseases

Frank J. Gaffney, MD, FACC

Dr. Gaffney is an interventional and noninvasive cardiologist with subspecialty expertise in transesophageal echocardiography, nuclear cardiology, and coronary angiography. Dr. Gaffney is Director of Cardiology at Bailey Medical Center. He completed his Cardiovascular Medicine Fellowship at Scott & White Memorial Hospital in Temple, Texas. Dr. Gaffney completed his Internal Medicine Internship and Residency at Brooke Army Medical Center in San Antonio. He then remained on staff at Scott & White Memorial Hospital for several years, before entering his Fellowship in Cardiovascular Medicine. Dr. Gaffney earned his medical degree from New York Medical College, Valhalla, New York, and he received his Bachelor of Arts degree at Hofstra University in Hempstead, New York.

Board certified in Internal Medicine, Cardiovascular Disease and Nuclear Cardiology

Eric G. Auerbach, MD, FACC

Dr. Auerbach is a general cardiologist whose major interest is preventive cardiology and cardiovascular risk reduction. He completed his Cardiology Fellowship at the University of Miami/Jackson Memorial Hospital in Miami, FL, following which he obtained additional subspecialty training in cardiovascular MRI, nuclear cardiology, and cardiac CT imaging. His areas of expertise also include echocardiography, stress testing and management of lipid disorders. In addition to holding board certification in cardiovascular disease, he is a diplomat of the American Board of Clinical Lipidology. Dr. Auerbach's Internal Medicine Internship and Residency were performed at the University of Miami/Jackson Memorial Hospital. He earned his medical degree at the University of Miami, Miami, FL, and his Bachelor of Arts degree at Princeton University, Princeton, NJ. Dr. Auerbach is the Director of Preventive Cardiology at Oklahoma Heart Institute, the medical director of The Weight Loss & Wellness Center at Oklahoma Heart Institute and a Clinical Associate Professor of Medicine at the University of Oklahoma College of Medicine – Tulsa.

Board certified in Internal Medicine, Cardiovascular Disease and Nuclear Cardiology

Robert L. Smith, Jr., MSc, MD, FACC, FSCAI

Dr. Smith specializes in interventional cardiology including cardiac catheterization, coronary angioplasty, and related interventional procedures such as coronary stents, atherectomy, intravascular ultrasound, and peripheral vascular interventional procedures. Dr. Smith is Director of Cardiology and the Cardiac and Interventional Laboratories at Hillcrest Hospital South. He completed an Interventional Cardiology Fellowship at the University of Florida College of Medicine in Jacksonville, FL. Dr. Smith performed his Clinical Cardiology Fellowship at Vanderbilt University School of Medicine in Nashville, TN and Tulane University School of Medicine in New Orleans. He received his medical degree from the University of Oklahoma College of Medicine in Oklahoma City and then completed his Internal Medicine Internship and Residency at Emory University School of Medicine in Atlanta, GA. Dr. Smith received his Bachelor of Arts, Bachelor of Science and Master of Science degrees at the University of Oklahoma in Norman, OK.

Board certified in Internal Medicine, Cardiovascular Disease, Interventional Cardiology and Nuclear Cardiology

Craig S. Cameron, MD, FACC, FHRS

Dr. Cameron is a specialist in cardiac electrophysiology, including catheter ablation of arrhythmias, atrial fibrillation management, pacemakers, implantable defibrillators, and cardiac resynchronization devices. Dr. Cameron is Director of Electrophysiology at Hillcrest Hospital South. He completed his Cardiac Electrophysiology Fellowship and his Cardiovascular Disease Fellowship at Baylor University Medical Center in Dallas, TX. Dr. Cameron's Internship and Internal Medicine Residency were performed at Baylor College of Medicine in Houston. He earned his medical degree from the University of Kansas School of Medicine in Kansas City, KS. Dr. Cameron received his Bachelor of Science degree at Pittsburg State University in Pittsburg, KS.

Board certified in Cardiovascular Disease and Cardiac Electrophysiology

Eugene J. Ichinose, MD, FACC

Dr. Ichinose specializes in interventional cardiology including cardiac catheterization, coronary angioplasty and related interventional procedures such as coronary stents, atherectomy, intravascular ultrasound and peripheral vascular interventional procedures. Dr. Ichinose is Director of Vein Services at Hillcrest Medical Center. He completed his Interventional and Clinical Cardiology Fellowships and his Internal Medicine Residency at the University of Massachusetts Memorial Health Care Center in Worcester, MA. Dr. Ichinose received his medical degree from Louisiana State University in New Orleans. He earned his Bachelor of Science degree from Texas Christian University in Fort Worth, TX.

Board certified in Internal Medicine, Cardiovascular Disease, Interventional Cardiology and Nuclear Cardiology

Cristin M. Bruns, MD

Dr. Bruns is a specialist in Endocrinology, Diabetes and Metabolism at Oklahoma Heart Institute, with expertise in diabetes, thyroid disease (including thyroid cancer) and polycystic ovary syndrome. She completed her Internal Medicine Internship and Residency and Endocrinology Fellowship at the University of Wisconsin Hospital and Clinics in Madison, WI. Dr. Bruns earned her medical degree from Saint Louis University School of Medicine in St. Louis, MO and her Bachelor of Arts and Bachelor of Science degrees in biology from Truman State University in Kirksville, MO. Prior to joining Oklahoma Heart Institute, Dr. Bruns worked as a clinical endocrinologist at the Dean Clinic in Madison, Wisconsin.

Board certified in Internal Medicine, Endocrinology and Metabolic Diseases

John S. Tulloch, MD

Dr. Tulloch is a noninvasive cardiologist with expertise in adult echocardiography, peripheral vascular imaging, nuclear cardiology, cardiac computed tomography and MRI. Dr. Tulloch is Director of the Cardiac and Vascular Ultrasound Department of Oklahoma Heart Institute/Hillcrest Medical Center's Cardiovascular Diagnostics. He completed his Cardiovascular Fellowship at the University of Kansas Medical Center in Kansas City, KS. Dr. Tulloch's Internal Medicine Internship and Residency also were completed at the University of Kansas Medical Center. He earned his medical degree from Ross University School of Medicine in New Brunswick, NJ and received his Bachelor of Science degree in biology from Avila University in Kansas City, MO.

Board certified in Internal Medicine, Cardiovascular Disease, Cardiovascular Tomography, and Nuclear Cardiology

Anthony W. Haney, MD, FACC

Dr. Haney is a noninvasive cardiologist with expertise in nuclear cardiology, echocardiography, peripheral vascular imaging and MRI. He also performs diagnostic cardiac catheterization. He completed his Cardiovascular Fellowship at the Medical College of Virginia in Richmond. Dr. Haney's Internal Medicine Internship and Residency were completed at the Mayo Clinic in Scottsdale, AZ. He earned his medical degree from the University of Oklahoma School of Medicine.

Board certified in Internal Medicine, Cardiovascular Disease and Nuclear Cardiology

Ralph J. Duda, Jr., MD, FACP, FACE, FASH, FNLA

Dr. Duda is a specialist in Endocrinology, Diabetes and Metabolism at Oklahoma Heart Institute, with expertise in diabetes, lipids, hypertension and thyroid diseases. Dr. Duda is Director of the Diabetes Education Center at Hillcrest Medical Center. He completed his Fellowship in Endocrinology and Metabolism at the Mayo Graduate School of Medicine, where he also completed his Residency in Internal Medicine. Dr. Duda received his medical degree from Northwestern University School of Medicine in Chicago, IL. He earned his Bachelor of Science degree from Benedictine University in Lisle, IL.

Board certified in Internal Medicine, Endocrinology, Diabetes and Metabolism, Clinical Lipidology, Clinical Hypertension, Clinical Bone Densitometry and Thyroid Ultrasonography

Douglas A. Davies, MD, FACC, FASNC

Dr. Davies is a hospital-based cardiologist who provides continuity of care for patients admitted to Oklahoma Heart Institute – Hospital. He completed a Clinical Cardiology Fellowship and additional training in nuclear cardiology at the Medical College of Virginia, where he also completed his Internal Medicine and Residency programs. Dr. Davies received his medical degree from Johns Hopkins University School of Medicine in Baltimore.

Board Certified in Internal Medicine, Cardiovascular Disease, Nuclear Cardiology and Cardiovascular Computed Tomography Angiography

Neil Agrawal, MD

Dr. Agrawal is a noninvasive cardiology specialist with expertise in adult echocardiography, nuclear cardiology, cardiac computed tomography and MRI. He completed his Cardiovascular Fellowship at the University of Vermont. Dr. Agrawal's Internal Medicine Internship and Residency were completed at the University of Louisville, and he earned his medical degree from St. George's University in Granada, West Indies. Dr. Agrawal completed his Bachelor of Science degree in biochemistry at the University of Texas at Austin.

Board certified in Internal Medicine

Kamran I. Muhammad, MD, FACC, FSCAI

Dr. Muhammad is a subspecialist in interventional cardiology. In addition to expertise in traditional areas of interventional cardiology, such as coronary intervention (angioplasty, stent placement, atherectomy, intravascular imaging) and peripheral vascular and carotid artery intervention, Dr. Muhammad has a special interest and expertise in interventional therapies for structural and valvular heart disease including the percutaneous non-surgical replacement and repair of heart valves — TAVR and MitraClip. As such, he currently serves as the Director of the Structural Heart Disease Program at OHI.

With dedicated and advanced training in structural heart disease intervention from the world-renowned Cleveland Clinic, Dr. Muhammad has been a pioneer in this field in Oklahoma. He led a team of OHI physicians in performing the first transcatheter aortic valve replacements (TAVR) and first transcatheter mitral valve repairs (MitraClip) in Tulsa and the region. Under his direction, these programs are the most experienced and compre-

hensive programs of their kind in the state, providing our patients with expert care and class-leading technologies for the non-surgical treatment of structural and valvular heart diseases.

In addition to his clinical experience, Dr. Muhammad has authored many peer-reviewed articles and textbook chapters on important cardiology topics. He also serves as Clinical Associate Professor of Medicine at the University of Oklahoma College of Medicine — Tulsa.

Dr. Muhammad completed his Clinical Cardiology and Interventional Cardiology Fellowships at the Cleveland Clinic which included additional dedicated training in peripheral vascular and structural cardiac intervention. Dr. Muhammad completed his Internal Medicine Internship and Residency at Yale University where he was selected and served as Chief Resident. He earned his medical degree from the University of Massachusetts Medical School, graduating with top honors and election to the Alpha Omega Alpha (AΩA) honor society. Dr. Muhammad earned his Bachelor of Science degree in computer science from the University of Massachusetts, Amherst.

Board certified in Internal Medicine, Cardiovascular Disease, Nuclear Cardiology and Interventional Cardiology

Arash Karnama, DO, FACC

Dr. Karnama is a specialist in interventional cardiology, including cardiac catheterization, coronary intervention, nuclear cardiology, echocardiography (TEE/TTE), cardioversion, peripheral angiography, peripheral intervention, carotid angiography, intravascular ultrasound, atherectomy, and PTCA/stenting for acute myocardial infarction. He is Director of the Cardiology Department at Hillcrest Hospital Claremore. Dr. Karnama completed his Interventional and Clinical Cardiology Fellowships at Oklahoma State University Medical Center and his Internal Medicine Internship and Residency at the Penn State Milton S. Hershey Medical Center in Hershey, PA. Dr. Karnama received his medical degree from Des Moines University in Des Moines, IA and his Bachelor of Arts degree from the University of Iowa in Iowa City.

Board certified in Internal Medicine, Interventional Cardiology, Cardiovascular Disease, Nuclear Cardiology, and Cardiovascular Computed Tomography

Victor Y. Cheng, MD, FACC, FSCCT

Dr. Cheng joins Oklahoma Heart Institute after serving as cardiology faculty at Cedars-Sinai Medical Center and assistant professor at the University of California in Los Angeles. Dr. Cheng is Director of the Cardiac Computed Tomography Department at Oklahoma Heart Institute and Hillcrest Medical Center. He is a specialist in noninvasive heart and vascular imaging, particularly in cardiac computed tomography (CT), a topic on which he has published numerous original research publications addressing quality, clinical use, and novel applications. Dr. Cheng's training includes a Clinical Cardiology Fellowship and Advanced Cardiac Imaging Fellowship at Cedars-Sinai Medical Center, and an Internal Medicine Internship and Residency at the University of California in San Francisco. Dr. Cheng received his medical degree from Northwestern University in Chicago, IL and his Bachelor of Science degree from Northwestern University in Evanston, IL.

Board certified in Internal Medicine, Cardiovascular Disease, Nuclear Cardiology, Echocardiography and Cardiovascular Computed Tomography

Jana R. Loveless, MD

Dr. Loveless is a sleep specialist, with expertise in the diagnosis and treatment of sleep disorders. She is Director of the Sleep Medicine Program at Hillcrest Hospital Claremore, Hillcrest Hospital Henryetta, and Hillcrest Hospital South. Prior to joining Oklahoma Heart Institute, Dr. Loveless was with Nocturna of Tulsa. She completed her Internal Medicine Residency program at the University of Oklahoma, Tulsa, where she was Chief Resident. She also earned her medical degree from, the University of Oklahoma, Tulsa. Dr. Loveless completed graduate studies at Texas Tech University, and she earned her Bachelor of Arts degree at Davidson College in Davidson, North Carolina.

Board Certified in Internal Medicine and Sleep Medicine

Mathew B. Good, DO, FACC, RPVI

Dr. Good is an invasive/noninvasive cardiology specialist with expertise in adult echocardiography, nuclear cardiology, cardiac computed tomography, peripheral vascular ultrasound and MRI. He completed his Cardiovascular Fellowship at the University of Kansas Medical Center in Kansas City, KS, where he also completed his Internal Medicine Internship and Residency. Dr. Good received his medical degree from the Oklahoma State University Center for Health and Sciences in Tulsa and his Bachelor of Arts degree from the University of Colorado in Boulder.

Board certified in Internal Medicine and Cardiovascular Computed Tomography

Stanley K. Zimmerman, MD, FACC, FSCAI

Dr. Zimmerman is the Director of the Catheterization Laboratory and Peripheral Vascular Services at Hillcrest Hospital South. He is the medical director of OHI vascular imaging laboratory. He is a specialist in interventional cardiology, including cardiac catheterization, coronary angioplasty, and related interventional procedures such as coronary stents, atherectomy, vascular ultrasound, and peripheral interventional procedures. Dr. Zimmerman specializes in complex vascular interventions, endovascular repair of abdominal aortic aneurysms and complex aorto-iliac disease, treatment of critical limb ischemia, and vascular management of arterial and venous based wounds.

He completed his Interventional and Cardiovascular Fellowships at the University of Kansas Medical Center in Kansas City, KS, as well as his Internal Medicine Internship and Residency. In addition, Dr. Zimmerman received his medical degree from the University of Kansas Medical Center and his Bachelor of Arts degree from the University of Kansas in Lawrence.

Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

Stephen C. Dobratz, MD, FACC

Dr. Dobratz specializes in diagnostic and interventional cardiology, including cardiac catheterization, peripheral angiography, pacemakers and defibrillators, cardioversion, cardiac nuclear studies, cardiac computed tomography, transesophageal echo and echocardiograms. Dr. Dobratz is Director of the Cardiac Catherization Laboratories at Hillcrest Hospital Claremore. He completed his Fellowship in Cardiology at Allegheny General Hospital in Pittsburgh, Pennsylvania. Dr. Dobratz completed his Internal Medicine Internship and Residency at the University of Arizona in Tucson. He earned his medical degree at Eastern Virginia Medical School in Norfolk and his undergraduate degree at James Madison University in Harrisonburg, Virginia.

Board certified in Cardiovascular Disease

Michael Phillips, MD, FACC, FACS

Dr. Phillips is a Cardiovascular Thoracic Surgeon at Oklahoma Heart Institute. He completed his fellowship at Mid America Heart Institute in Kansas City, MO and his general surgery residency at the Mayo Graduate School of Medicine. He earned his medical degree from the University of Missouri. Dr. Phillips received his undergraduate degrees in Biology and Chemistry at William Jewell College in Liberty, MO.

Board certified by in Thoracic and General Surgery

James B. Chapman, MD, FACC, FSCAI

Dr. Chapman is a specialist in interventional cardiology, including cardiac catheterization, coronary angioplasty and related interventional procedures such as stents, atherectomy, laser, intravascular ultrasound imaging and direct PTCA for acute myocardial infarction. He completed a Clinical Cardiology Fellowship at St. Vincent Hospital and Health Care Center in Indianapolis, IN. He also completed his Internal Medicine Internship and Residency programs at St. Vincent. Dr. Chapman received his medical degree from Indiana University School of Medicine in Indianapolis and his Bachelor of Science degree from Indiana University in Bloomington, IN.

Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

Joseph J. Gard, MD, FACC, FHRS

Dr. Gard is a cardiologist who specializes in electrophysiology, complex ablation and atrial fibrillation management. He completed his Cardiac Electrophysiology Fellowship and his Cardiology Fellowship at the Mayo School of Graduate Medical Education in Rochester, Minnesota. Dr. Gard also performed his Internal Medicine Residency at Mayo. He earned his medical degree from the University of Nebraska in Omaha, Nebraska. Dr. Gard received his Bachelor of Science degree from Boston College in Chestnut Hill, Massachusetts.

Board certified in Cardiovascular Disease, Internal Medicine, Electrophysiology and Clinical Cardiac Electrophysiology

Edward J. Coleman, MD, FACC, FAHA, FACS, FCCP

Dr. Coleman is a cardiovascular surgeon who specializes in cardiac, thoracic and vascular surgery. He completed his residency in cardiothoracic surgery at State University of New York at Buffalo in Buffalo, New York. He was Senior & Chief Resident at Mary Imogene Bassett Hospital/ Columbia University College of Physicians & Surgeons in Cooperstown, New York. Dr. Coleman performed his Internship and Residency in general surgery at the University of Rochester School of Medicine & Dentistry in Rochester, NY. He earned his medical degree from State University of New York at Buffalo School of Medicine, Buffalo, New York. Dr. Coleman received his Bachelor of Arts degree from Norwich University in Northfield, Vermont.

Board Certified in General Surgery and Thoracic Surgery

Michael B. Newnam, MD

Dr. Newnam is Director of Sleep Medicine at Hillcrest Medical Center and Hillcrest Hospital Cushing. He is a Board Certified specialist in the diagnosis and treatment of sleep disorders. He completed his Family Practice Internship & Residency programs at the Womack Army Medical Center in Ft. Bragg, NC. Dr. Newnam earned his medical degree from the University of Oklahoma and his Bachelor of Science degree from Oral Roberts University in Tulsa, OK.

Board Certified in Family Medicine and Sleep Medicine

John M. Weber, MD, RPVI

Dr. Weber is a Peripheral Vascular Surgeon at Oklahoma Heart Institute who specializes in complex vascular disease. He offers both open and endovascular treatment of arterial and venous disease. Areas of interest include open and endovascular treatment of aortic pathology, cerebrovascular surgery, limb salvage surgery, vascular access, and complex venous therapies. He completed his residency in Vascular Surgery at the Cleveland Clinic in Cleveland, Ohio. Dr. Weber earned his medical degree at the University of Oklahoma College of Medicine. He also completed his undergraduate degree at the University of Oklahoma.

David Liff, MD

Dr. Liff is an interventional cardiologist who specializes in peripheral vascular disease as well as coronary interventional disease. He completed a Peripheral Interventional Fellowship at Ochsner Clinic in New Orleans, LA. and an Interventional Cardiology Fellowship at Hofstra/North Shore Univer-

sity /Long Island Jewish Hospital Center in New York. Dr Liff completed his Clinical Cardiology Fellowship at Emory University Hospital System in Atlanta, GA. He also performed his Internal Medicine Internship and Residency at Emory. Dr. Liff earned his medical degree from Ohio State University School of Medicine. He received his Bachelor of Science degree from the University of Michigan in Ann Arbor, MI.
Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

Saran Oliver, MD

Dr. Oliver is an invasive/noninvasive cardiology specialist with specific interests in adult echocardiography, nuclear cardiology, and women's cardiovascular health. She completed her Cardiovascular Fellowship at Scott and White Memorial Hospital in Temple, TX. Dr. Oliver performed her Internal Medicine Internship and Residency at the University of Texas Southwestern Medical Center in Dallas, TX. She also earned her medical degree from the University of Texas Southwestern Medical Center. Dr. Oliver attended Rice University in Houston, TX where she received her Bachelor of Arts degree in Sports Medicine.
Board certified in Internal Medicine, board eligible in Cardiovascular Medicine

Lauren LaBryer, MD

Dr. LaBryer is a specialist in Endocrinology, Metabolism and Hypertension at Oklahoma Heart Institute. She completed her Endocrinology Fellowship at the University of Oklahoma College of Medicine. She also completed her Internal Medicine Internship and Residency Programs at Oklahoma, where she was selected as Chief Resident in Medicine. In addition, Dr. LaBryer earned her medical degree from the University of Oklahoma College of Medicine. She received her Bachelor of Science degree in Biopsychology and Cognitive Sciences from the University of Michigan.
Board certified in Internal Medicine, Endocrinology and Metabolic Diseases

Jordan A. Brewster, MD

Dr. Brewster is a specialist in electrophysiology, with expertise in electrophysiology, complex ablation, and atrial fibrillation management. He completed his Fellowship in Electrophysiology at Indiana University in Indianapolis, IN. Dr. Brewster performed his Fellowship in Cardiovascular Disease at the University of Kentucky Division of Cardiovascular Medicine in Lexington, KY, where he was Chief Fellow. He completed his Internal Medicine Internship and Residency at Vanderbilt University in Nashville, TN. Dr. Brewster received his medical degree from the University of Virginia School of Medicine in Charlottesville, VA. and his Bachelor of Science degree in Biochemistry from the University of Oklahoma.
Board certified in Internal Medicine, Cardiovascular Disease and Nuclear Cardiology

Ahmad Iqbal, MD

Dr. Iqbal is an invasive/noninvasive cardiologist at Oklahoma Heart Institute who specializes in advanced heart failure patients, including those with left ventricular assist devices (LVAD) as well as patients with cardiac transplantation. His special interest is mechanical circulatory support options for patients requiring additional life support measures including ECMO, Impella, and LVADs. Dr. Iqbal also is a diplomate of the National Board of Echocardiography and specializes in adult comprehensive echocardiography, including stress echocardiography and transesophageal echocardiography. He also has an interest in nuclear and preventative cardiology. He completed his Advanced Heart Failure and Transplant Fellowship at Northwestern University Feinberg School of Medicine in Chicago, IL. Dr. Iqbal completed his Cardiovascular Disease Fellowship at Mid America Heart Institute at St. Luke's Hospital/University of Missouri-Kansas City, MO. Dr. Iqbal completed his Internal Medicine Residency at the University of Texas Southwestern in Dallas, TX. He received his medical degree from Tulane University School of Medicine and his Bachelor of Business Administration degree from Loyola University in New Orleans, LA, where he graduated summa cum laude.
Board certified in Internal Medicine, Cardiovascular Diseases, and Echocardiography. Board eligible in Nuclear Cardiology. Board eligible in Advanced Heart Failure and Transplant

Mrudula R. Munagala, MD, FACC

Dr. Munagala is Director of the Advanced Heart Failure program at Oklahoma Heart Institute. She specializes in Heart Failure, Mechanical Circulatory Support Devices (MCSD) and Transplant. Dr. Munagala is also experienced in managing patients with Pulmonary Hypertension and Cardiac Heart and Lung amyloidosis. She undertook advanced training in Heart Failure, MCSD and Transplant fellowship at UCLA-Ronald Reagan Medical Center in Los Angeles, CA after completing her Internal Medicine residency and Cardiovascular Diseases fellowship at Drexel University College of Medicine, Philadelphia, PA. She also completed a Heart Failure and Pulmonary Hypertension fellowship at Allegheny General Hospital, Pittsburgh, PA. Dr. Munagala received her medical degree from Sri Venkateswara Medical College in Andhra Pradesh, India. She has been involved in clinical research in Heart Failure, Ventricular Assist Devices (VAD) and Transplant and authored several articles and book chapters. She is an active member in various professional societies, including the American College of Cardiology, Heart Failure Society of America, International Society of Heart and Lung Transplant and American Medical Association.
Board Certified in Internal Medicine, Cardiovascular Diseases, Heart Failure and Transplant, Echocardiography and Nuclear Cardiology

Siva Soma, MD, FACC, FHRS

Dr. Soma is a specialist in electrophysiology, with expertise in complex catheter ablation of cardiac arrhythmias and management of atrial fibrillation, ventricular tachycardia, pacemakers, defibrillators and cardiac resynchronization devices.

He completed his Fellowship in Electrophysiology at the University of Pittsburgh Medical Center in Pittsburgh, PA. Dr. Soma performed his Fellowships in Cardiovascular Disease and Advanced Heart Failure/Transplantation at Allegheny General Hospital in Pittsburgh. He completed his Internal Medicine Internship and Residency at Hahnemann University Hospital, Drexel University College of Medicine in Philadelphia, PA.

Dr. Soma completed a Master's degree in public health and received his medical degree from Armed Forces Medical College in India.
Board certified in Internal Medicine, Cardiovascular Disease and Nuclear Cardiology

Ajit K. Tharakan, MD, M.Ch, FACS

Dr. Tharakan is a Cardiovascular Thoracic surgeon at Oklahoma Heart Institute. He was Chief Resident of Cardiothoracic Surgery at Massachusetts General Hospital, Harvard Medical School, Boston, MA, as well as Chief Resident of Cardiovascular Surgery at Boston Children's Hospital, Harvard Medical School, Boston, MA.

He was also Chief Resident for General Surgery at the Hugh E. Stephenson Department of Surgery, School of Medicine, University of Missouri, Columbia, MO, where he did his General Surgery Residency. He also was Chief Resident in Cardiothoracic Surgery at Christian Medical College & Hospital, Vellore, Tamilnadu, S. India. Dr. Tharakan has done additional training at St. John's National Academy of Health Sciences, Bangalore, India and Christian Medical College Hospital, Vellore, India where he secured the M.Ch (Master of Chirurgi) degree.

Dr. Tharakan performed his Internship at Sri Ramachandra Medical College & Research Institute, The Tamilnadu Dr. M.G.R. Medical University, Porur Madras, Tamilnadu, India, where he also earned his medical degree. Prior to joining Oklahoma Heart Institute, Dr. Tharakan was the Director of Cardiothoracic Surgery at the Hugh E. Stephenson Department of Surgery at the University of Missouri-Columbia. He has numerous publications, patents, and inventions. He was recognized as one of MU's Top Faculty Achievers in 2017.
Board certified in Thoracic and General Surgery

Allen Cheng, MD

Dr. Cheng is a cardiovascular surgeon who served as the Surgical Director of Heart Transplantation at Rudd Heart and Lung Center, Jewish Hospital, University of Louisville prior to joining Oklahoma Heart Institute.

He completed his general surgery residency at UCLA, cardiothoracic surgery training at Massachusetts General Hospital/Harvard Medical School, cardiovascular surgery postdoctoral fellowship at Stanford University and specialty training at University of Rochester.

Dr. Cheng specializes in heart transplantation, mechanical circulatory support, ECMO, minimally invasive cardiac surgery, atrial fibrillation surgery (MAZE), and transcatheter aortic valve replacement. He is also a scientific investigator at Cardiovascular Innovation Institute. Dr. Cheng has received multiple national awards including the Howard Hughes Medical Institute research award, American Heart Association (AHA) research award, Thoracic Surgery Foundation for Research and Education (TSFRE) research award and the Society of Heart Valve C. Walton Lillehei research award.

He has an extensive publication record in major international cardiovascular journals including Circulation, Annals of Thoracic Surgery, Journal of Heart and Lung Transplantation and ASAIO, and is also serving as a reviewer for the above journals.
Board certified in Surgery and Thoracic Surgery

Shahid Qamar, MD, FACC

Dr. Qamar is a cardiologist who specializes in advanced heart failure and mechanical circulatory support. Prior to joining Oklahoma Heart Institute, he served as Medical Director of the Heart Failure Clinic at Ascension Columbia St. Mary's Hospital in Milwaukee, WI.

He performed an Advanced Heart Failure Fellowship and a Transplant Fellowship at the University of Chicago in Chicago, IL. His General Cardiology Fellowship and Internal Medicine Residency were completed at Aurora Health Care in Milwaukee, WI

Dr. Qamar completed his General Surgery Residency at the Dow University of Health Sciences in Karachi, Pakistan, where he also earned his medical degree.
Board Certified in Internal Medicine and Cardiology

Adele M. Barkat, MD

Dr. Barkat is a Vascular Surgeon at Oklahoma Heart Institute, who specializes in vascular and endovascular cases, including cerebrovascular, aortoiliac and infrainguinal occlusive disease, abdominal aneurysms, visceral arterial disease, arteriovenous access and venous interventions.

He performed a Vascular Surgery Fellowship at Loyola University Medical Center in Chicago, IL. Dr. Barkat completed his General Surgery Residency at Louisiana State University Health and Sciences Center in New Orleans, LA. He earned his medical degree at Louisiana State University Medical Center.

Dr. Barkat completed his Bachelor of Science degree at Louisiana State University with a degree in Biochemistry.

Mitral Valve Repair for Degenerative Valve Disease

By Ajit K. Tharakan, MD — Cardiothoracic Surgery, Oklahoma Heart Institute

Mitral valve repair is the preferred surgical treatment for mitral regurgitation regardless of its etiology. However, it has its greatest application and success in correcting mitral regurgitation in patients with degenerative valvular disease. Numerous studies have documented that mitral valve repair performed by standardized techniques is reproducible and associated with low operative morbidity and mortality. The advantages of mitral valve repair over mitral valve replacement include a lower operative mortality, better preservation of left ventricular function, and higher freedom from thromboembolism, anticoagulant-related hemorrhage, and endocarditis. Over the last couple of decades, mitral repair has been widely applied as the preferred treatment for degenerative mitral repair.

In the following article, I will discuss the surgical anatomy, pathology of degenerative mitral valve disease, surgical principles and the contemporary results of mitral valve repair in degenerative valve disease.

Surgical Anatomy of the Mitral Valve

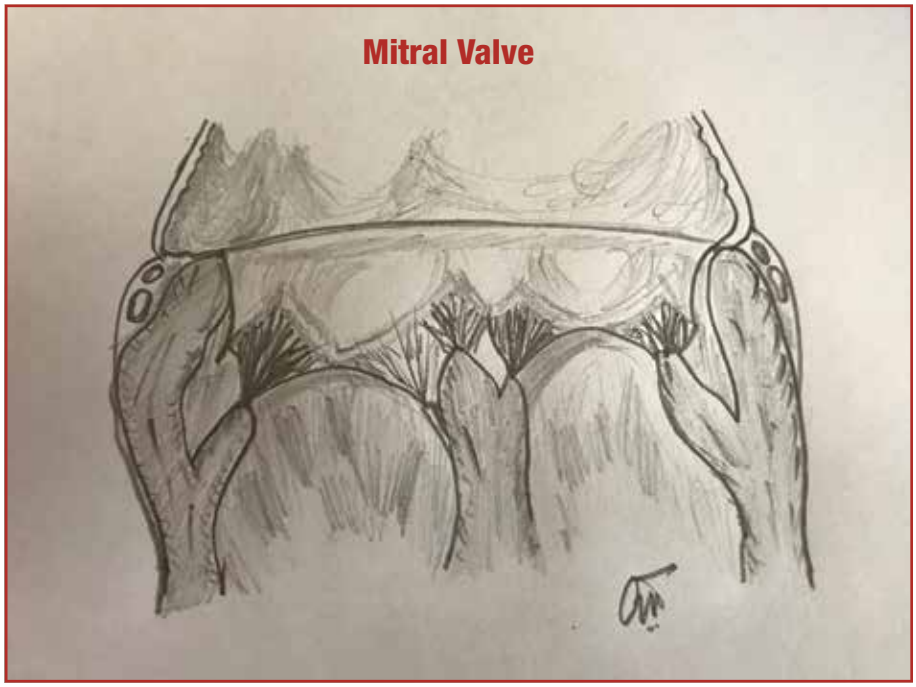
The mitral valve is a multidimensional unit which functions to maintain competence of the valve during systole and allows the left ventricle to fill unrestricted during diastole. The components of the functional mitral valve include the valve annulus, the leaflets, the chordae tendinae, papillary muscles and the left ventricular free wall.

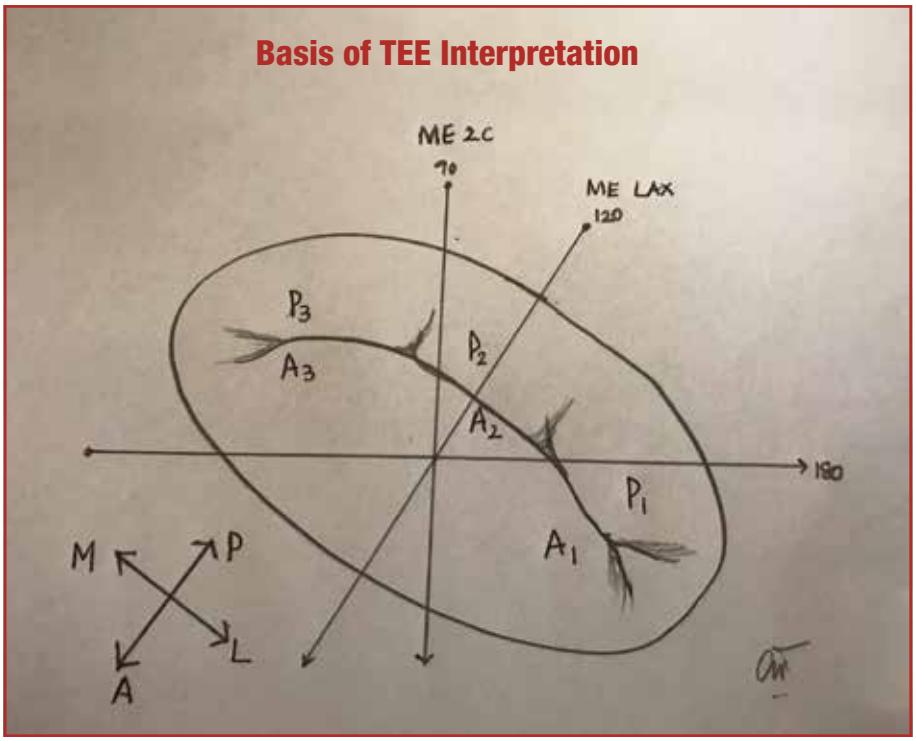
Leaflets

There are two leaflets of the mitral valve — the anterior or aortic leaflet and the posterior or mural leaflet. The anterior leaflet is the broader of the two leaflets, comprises one third of the annular circumference and has a clear and rough zone. The distinguishing feature of this leaflet is the fibrous continuity with the left and non-coronary cusps of the aortic valve and with the interleaflet trigone. The aortic leaflet is also divided arbitrarily into three regions labelled A1, A2 and A3 corresponding to the adjacent regions of the mural leaflet.

The posterior leaflet is narrow and extends two-thirds around the left atrioventricular junction within the inlet portion of the ventricle. In adults, the mural leaflet has indentations that form three scallops along the elongated free edge.

Carpentier's nomenclature describes the most lateral segment as A1- P1, which lies adjacent to the anterolateral commissure, A2-P2 is central and can significantly vary in size, and most medial is A3-P3 segment, which lies adjacent to the posteromedial commissure.





Annulus

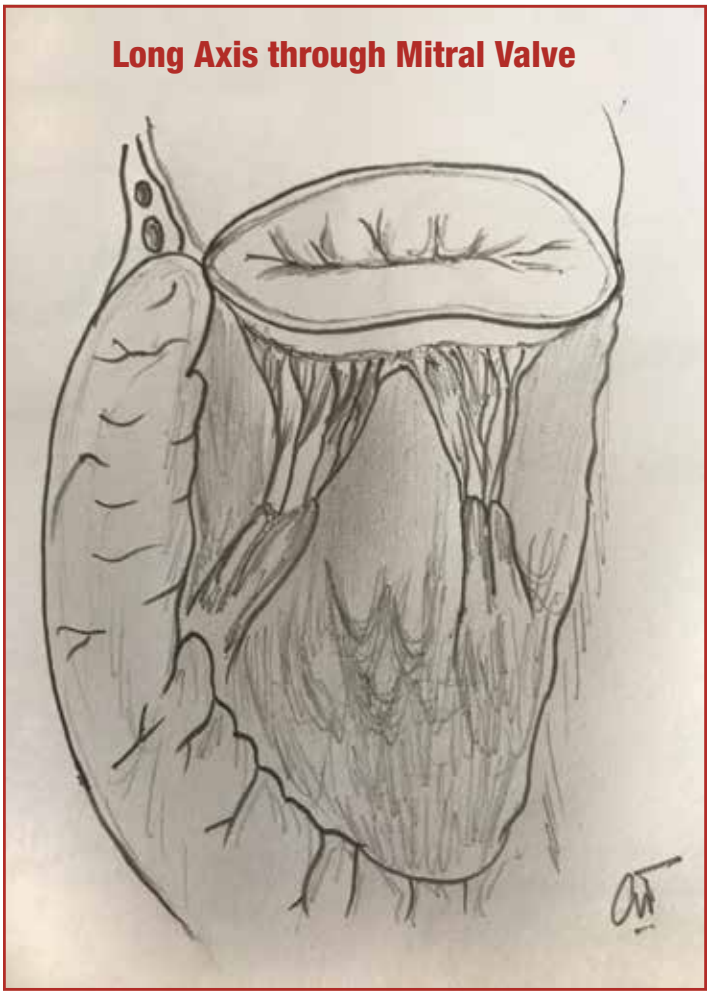
The term annulus is used to describe the junctional zone which separates the left atrium and left ventricle and this also gives attachment to the leaflets of the mitral valve. It is not a complete fibrous ring but pliable, changing shape during the cardiac cycle. The annulus has an elliptical shape, the commissural diameter being larger than the antero-posterior diameter. The aortic valve is in fibrous continuity with the anterior leaflet and the right and left fibrous trigones. This region of the annulus is thus fibrous and less prone to dilatation. Beyond this point, the remaining two-thirds of the annulus are mainly muscular which is where the annular dilatation occurs during conditions of volume overload of the left ventricle.

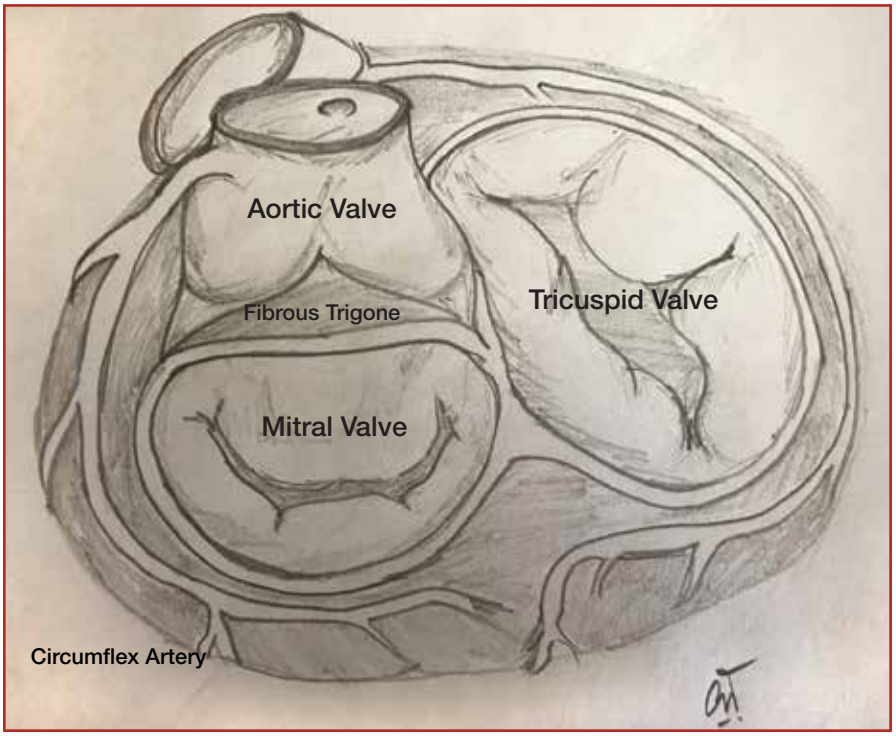
Chordae tendinae

In the normal valve, the leaflets have fan-shaped chords running from the papillary muscles and inserting into the leaflets. Depending on their attachment on the leaflet, there are three types of chordae tendinae. Primary chords attach to the free edge of the rough zone of both leaflets. Secondary chords attach to the ventricular surface in the region of the body of the leaflet. The tertiary chords are found in the posterior leaflet only, which has a basal zone. These chords attach directly to the ventricular wall. The posteromedial papillary muscle gives chords to the medial half of both and the anterolateral papillary muscle chords attach to the lateral half of the leaflets.

Papillary muscles

The papillary muscles are described as anterolateral and posteromedial and are positioned along the mid to apical segments of the left ventricle. The anterolateral papillary muscle is usually seen to attach at the border of the anterolateral and inferolateral walls, and the posterolateral papillary muscle over the inferior wall of the left ventricle. The muscular content and its attachments can vary significantly, particularly in patients with myxomatous type leaflets (degenerative MV disease). The papillary muscles can also be diseased in ischemic heart disease. The blood supply of the anterolateral papillary muscle is most commonly from the left anterior descending artery, but may also be from the diagonal, a proximal marginal branch or a ramus intermedius artery. The posteromedial papillary muscle is supplied from the posterior circulation either by way of the right coronary artery or the distal circumflex artery.





Left ventricular free wall

The papillary muscles are attached to the free wall of the ventricle and alterations in the dimensions of the ventricle can affect the function of the valve. If the ventricle becomes dilated from volume overload the tethering of the valvular apparatus can cause alterations in the coaptation and function of the valve.

Surrounding structures

The mitral valve apparatus is closely related to several important structures. As described above, the aortic valve is closely related to the anterior mitral leaflet, the left circumflex coronary artery is closely related to the posterior annulus and the coronary sinus is also related to the posterior annulus. During mitral valve surgery, great care and attention need to be taken to prevent injury to these structures.

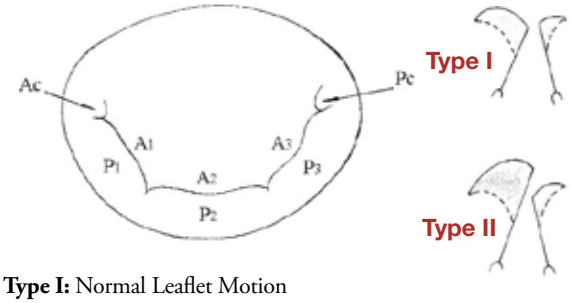
Pathology of the mitral valve and its surgical relevance

Mitral valve function is dependent on coaptation of the valve leaflets and symmetric apposition to prevent regurgitation. There are many ways in which valve failure may occur and it is important to establish the etiology and the anatomic mechanisms involved in valve failure.

(continued on p. 18)

Alain Carpentier in his seminal paper in 1983: Cardiac Valve Surgery — the "French Correction", and later modified by him in 1995 to include Type IIIb as a mechanism of leaflet restriction during systole causing regurgitation.

The classification is as follows:

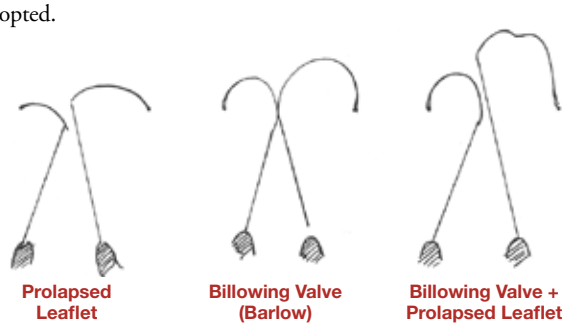


- **Type I:** Normal Leaflet Motion
  - » Annular dilation, Leaflet perforation
- **Type II:** Leaflet Prolapse
  - » Chordal Rupture, Chordal Elongation, Papillary muscle rupture, Papillary muscle elongation
- **Type III:** Restricted Leaflet Motion Type IIIa: During diastole
- **Type IIIb:** During systole

The Carpentier classification is defined surgically as follows. The mitral valve leaflet posterior scallops are identified as P1 (anterior scallop), P2 (middle scallop), and P3 (posterior scallop) as viewed by the surgeon though a left atriotomy. The three corresponding segments of the anterior leaflet are termed A1 (anterior part), A2 (middle part), and A3 (posterior part). The remaining two segments are the anterior commissure (Ac) and posterior commissure (Pc).

The regions of the mitral valve leaflets are defined surgically through a left atriotomy by taking nerve hooks and lifting each posterior leaflet scallop and their corresponding, coapting anterior leaflet. The posterior leaflet P1 scallop coapts with A1. The posterior leaflet P2 scallop coapts with A2. The posterior leaflet P3 scallop coapts with A3. Surgical pathology was then defined by leaflet section: P1/A1, P2/A2, P3/A3. Also important is the understanding of papillary muscle — chordal – leaflet scallop relationship.

When the ASE/SCA developed their echocardiographic terminology for mitral valve leaflets the Carpentier terminology of mitral valve leaflet scallops was adopted.



The most common etiologies for mitral regurgitation are degenerative (60%), rheumatic (post-inflammatory, 12%) and functional (25%). The latter includes 'ischemic' mitral regurgitation. Other less common causes include congenital abnormalities and endocarditis. With all these etiologies mitral annular (or orifice), dilatation is observed to varying degrees.

Degenerative mitral valve disease

The term 'degenerative' covers a range of abnormalities where the primary pathology includes thickening and stretching due to disruption of the structural collagen core of the leaflet tissue. The abnormal leaflets therefore become elongated. This involvement could be local to one segment of one leaflet, through to all segments of both leaflets. The former has been coined 'fibroelastic deficiency' by Carpentier, whereas the latter describes Barlow's disease with myxomatous-type leaflets.

In fibroelastic deficiency, often the prolapsing segment is relatively normal in appearance; the prolapse being the result of focal chordal elongation with or without rupture. At the other end of the spectrum, the widespread involvement of most of the segments is seen. This process affects the subvalvular structures with chordal thinning and elongation. This results in the affected leaflet segments ballooning into the left atrium. Echocardiographically, they are described as 'prolapsing' back into the atrium. The posterior leaflet is the most frequent area to develop thickening. Mechanical stresses on the degenerative chords have the propensity to rupture. If this involves the primary chords (to the leaflet rough zone), then there maybe total eversion of the leaflet free edge into the left atrium. This is described as a 'flail' segment and its recognition is helpful as it is inevitably associated with severe regurgitation. The same disease process can result in focal regions of thickening with retraction and restriction, although this is far less common.

Surgical Approach to mitral valve repair

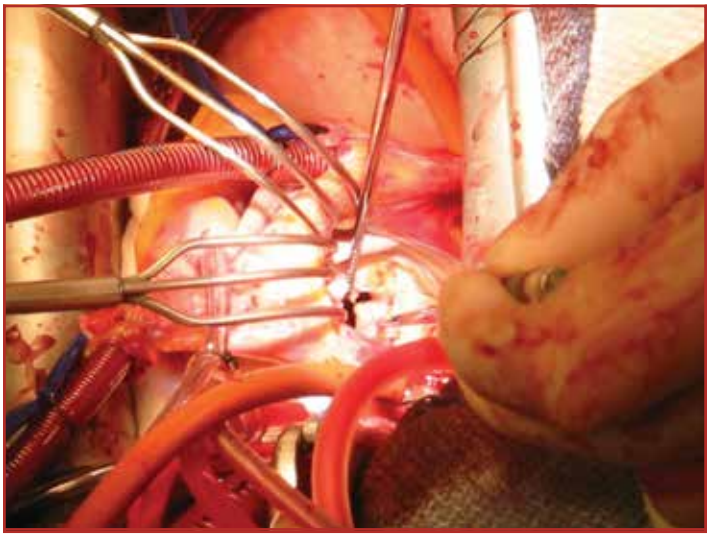
Echocardiography has become the cornerstone of diagnosis and the basis for the anatomic definition of valve abnormalities. When planning surgery to repair and degenerative mitral valve it is important to define the entire mitral anatomic complex, the mechanisms of regurgitation, the size of the left atrium and degree of left ventricular function and size, the right ventricular function and tricuspid valve function.

Techniques for surgical mitral valve repair

Mitral valve repair has become the standard for surgery in patients with degenerative mitral valve disease with repair rates of 60-90% been reported in literature.

Surgery is accomplished by standard sternotomy approaches as well as minimally invasive approaches. Cardiopulmonary bypass is achieved by aortic and bicaval cannulation. Vacuum drainage is highly beneficial to assist venous drainage. The exposure of the valve can be achieved by a standard inferior approach, a transeptal approach or a superior septal approach. A systematic assessment of the mitral valve and left atrium should now ensue. Jet lesions should be noted. Nerve hooks are then used to define the presence and amount of chordal elongation.

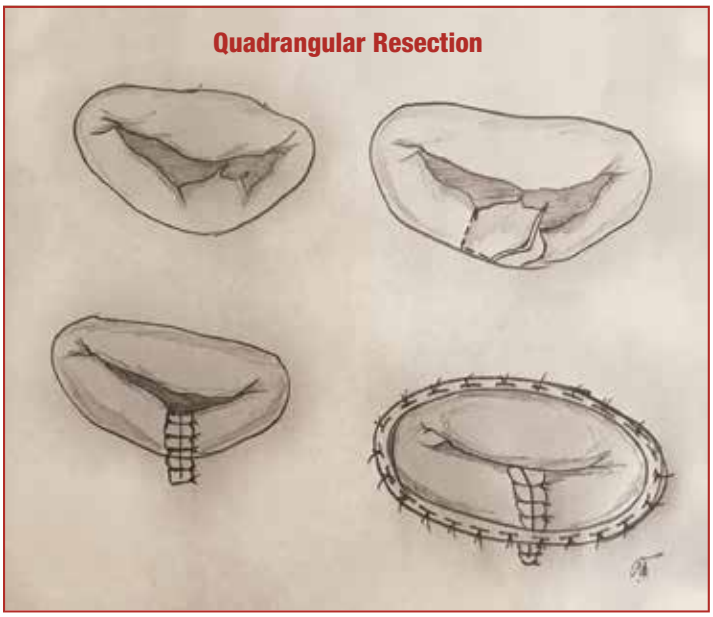
Exposure of Mitral Valve



Classic repair:

A flail portion of the posterior leaflet is treated by resection of the unsupported portion of the leaflet. One or two pledgetted sutures are used to reinforce the annulus at the site of leaflet resection, and the leaflet is repaired with running 5–0 or 4-0 nonabsorbable sutures. Although the middle scallop of the posterior leaflet is most commonly affected, up to 60% of the posterior leaflet may be resected. A posterior annuloplasty completes the repair.

Classic Repair



Additional techniques:

Ruptured chordae in separate areas of the posterior leaflet are repaired by separate leaflet resections.

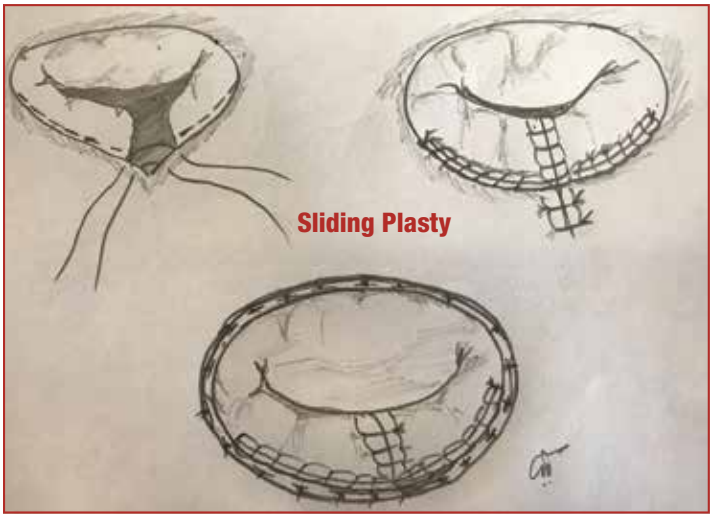
Chordal transfer: The free edge of the anterior leaflet may be supported by detaching a convenient secondary chord from the ventricular surface of the anterior leaflet and suturing it to the unsupported free edge.

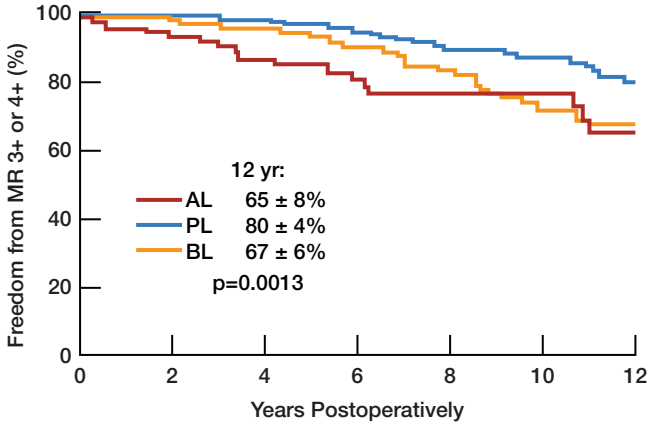
Sliding leaflet repair

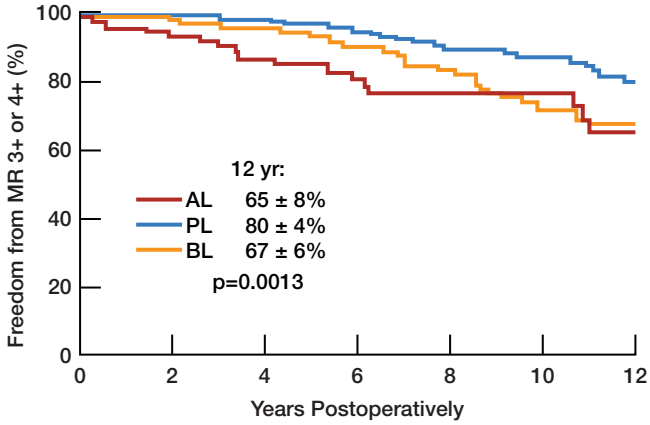
Repair of the mitral valve in patients with advanced myxomatous degeneration and excessive leaflet tissue (Barlow's syndrome) requires special attention. The usual remodeling annuloplasty techniques may result in systolic anterior motion and left ventricular outflow tract obstruction. Excessive posterior leaflet tissue should be removed to avoid this complication. The condition is recognized by noting that the posterior leaflet is too wide as well as too long. The central portion of the posterior leaflet is resected, along with a curving wedge resection of the annulus on each side involving about half the posterior leaflet or all the widened portion of the valve. The reconstruction is completed as shown in the figure. The repair is supported and the annulus is remodeled with a rigid or semirigid annuloplasty ring attached to the annulus with interrupted mattress stitches of 2/0 braided suture.

Ring annuloplasty

Prosthetic ring annuloplasty can be used to reduce annular diameter, reshape the annulus, and strengthen the annular support of a valve leaflet repair. The prosthetic device may be a true circumferential ring or a partial ring designed to reduce only the annulus supporting the posterior leaflet. Prosthetic rings may be rigid or semirigid, designed to remodel the shape of the annulus of the mitral valve. Prosthetic ring size can be determined by a variety of methods, depending on the prosthetic device chosen for the repair. Methods of sizing are based on the length of the septal (anterior) leaflet at its annular connection because this dimension remains relatively unchanged during annular dilatation, which occurs almost exclusively in the annulus supporting the posterior leaflet at the free wall of the left ventricle. Sizing devices use the commissures of the mitral valve or the fibrous trigones as reference points. The surface area of the anterior leaflet should also be considered.







Results of mitral repair for degenerative disease

Mitral valve (MV) repair for mitral regurgitation (MR) caused by degenerative disease of the MV is feasible in more than 90% of patients. Prolapse of the posterior leaflet (PL) is the most common cause of MR, valve repair is relatively simple, and the long-term results have been excellent. Prolapse of the anterior leaflet (AL) and bileaflet (BL) prolapse are more difficult to repair, and the long-term results are not as good as those for repair of prolapse of isolated posterior leaflet (PL).

Dr. Tharakan is a Cardiovascular Thoracic surgeon at Oklahoma Heart Institute. His clinical work includes thoracic aortic surgery, coronary artery and valve surgery, transcatheter valve therapies, adult congenital surgery, lung cancer and thoracic surgery.

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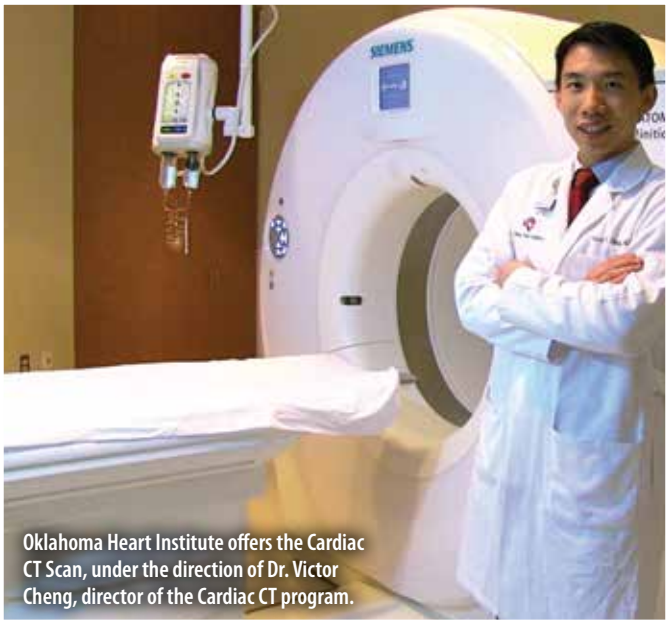
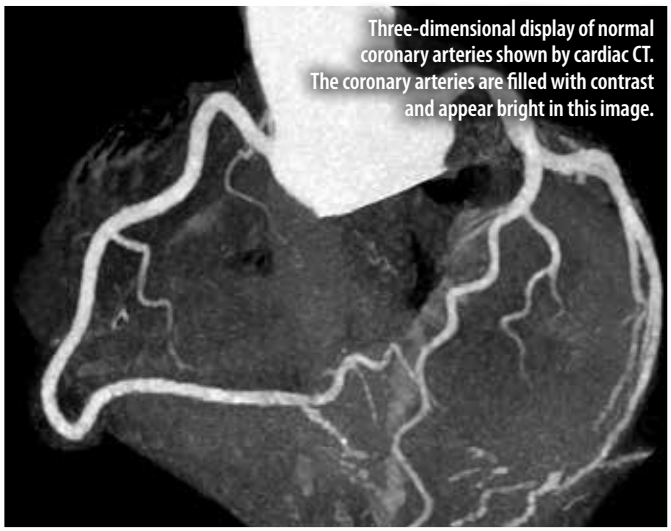


Oklahoma Heart Institute offers the Cardiac CT Scan, under the direction of Dr. Victor Cheng, director of the Cardiac CT program.



Three-dimensional display of normal coronary arteries shown by cardiac CT. The coronary arteries are filled with contrast and appear bright in this image.

Cardiac CT at Oklahoma Heart Institute

State-of-the-art scanner detects your risk for heart disease

Heart disease is the leading cause of death in the United States for men and women. But for many, the first symptom of heart disease is a heart attack.

In Tulsa, Oklahoma Heart Institute is changing that by offering a Cardiac CT Scan performed by a state-of-the-art ultrafast scanner that is more than 95 percent sensitive in detecting heart disease. The scanner creates detailed and accurate images of the heart and arteries in just seconds, all meaning easy and early detection of heart disease.

Dr. Victor Cheng administers this new technology at Oklahoma Heart Institute. Cheng, who came to OHI via Los Angeles' Cedars-Sinai Hospital, says using the Cardiac CT Scan is a good way to test if a patient's symptoms are due to heart disease or if a patient with significant risk factors has developed heart disease.

"For both symptomatic and asymptomatic individuals, Cardiac CT detects the presence and amount of plaque in the coronary arteries," Cheng says. "This information helps doctors tailor the intensity of recommended therapies to reduce heart attack risk and can motivate individuals to live a more heart-healthy lifestyle."

He adds, "For individuals with chest pain or breathlessness, Cardiac CT is the most reliable noninvasive test to show that the person does not have significant coronary artery blockage. The use of Cardiac CT in this situation determines whether additional evaluation or treatment for coronary artery disease is needed."

Cardiac CT is a painless screening test that uses an X-ray machine to take clear, detailed pictures of a heart and blood vessels. The scanner uses 50-90 percent less radiation than earlier generation scanners. The average patient is exposed to a radiation dosage comparable to a mammogram. This one-time radiation exposure is considered quite safe.

For individuals concerned about, or are at risk for, heart disease, Cardiac CT detects if there is no disease, mild disease or severe disease. Cardiac CT also effectively determines presence of heart disease in those who have undergone a stress test with an inconclusive result.

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SPICY TORTILLA SOUP WITH BLACK BEANS Serves 8

This simple, spicy soup is great for parties. Create a build-your-own soup bar with avocado, cashew sour cream, chopped lettuce, red onion and loads of fresh herbs, and let your guests create their own delicious bowls.

4 corn tortillas

1 large yellow onion, peeled and diced (about 1 cup)

1 jalapeño, seeded and diced

2 tablespoons Mexican Spice Blend

Zest and juice of 1 lime, divided

2 (28-ounce) cans no-salt-added diced tomatoes (or 4 pounds fresh, chopped)

1/4 cup chopped fresh cilantro

1 (15-ounce) can black beans, drained and rinsed, for garnish

1 avocado, diced, for garnish

Preheat the oven to 350°F. Place tortillas in a single layer on a rimmed baking sheet. Cook tortillas about 10 minutes, flipping halfway through. Remove from the oven when chip-like. Break into bite-size pieces.

CASHEW SOUR CREAM

Makes about 1 1/4 cups

1 cup raw cashews
2 teaspoons cider vinegar
1 teaspoon lemon juice
1/8 teaspoon fine sea salt

Place cashews in a cup or small bowl and cover by about 1/2 inch with boiling water. Let soak 30 minutes.

Drain cashews and place in a blender with vinegar, lemon, salt and about 1/4 cup water. Blend until very smooth, adding more water as required to purée the mixture.

MEXICAN SPICE BLEND

Makes about 6 tablespoons

2 tablespoons paprika
2 tablespoons no-salt-added chili powder
1 1/2 teaspoon onion powder
1 1/2 teaspoon garlic powder
1 1/2 teaspoon ground cumin
1 1/2 teaspoon ground black pepper
1/4 teaspoon cayenne or ground chipotle pepper (optional)

HEARTY RYE BERRY SALAD WITH CHICKEN Serves 4

Rye berries are an easy-to-make, chewy whole grain that works well with many flavors. Use leftover chicken or pick up a rotisserie chicken and shred the breast meat.

1 cup rye berries

2 cups shredded cooked chicken breast

2 cups packed baby spinach leaves, chopped

1 cup dried cranberries

1/2 cup crumbled goat cheese

1/2 cup toasted chopped pecans

1/2 teaspoon fine sea salt

Place rye berries and 2 1/2 cups water in a medium saucepan and bring to a boil. Reduce heat to low, cover and simmer about 1 hour or until tender. Drain well.

Place drained rye berries in a large bowl. Add chicken, spinach, cranberries, goat cheese, pecans and salt and toss until evenly blended. Serve warm.

SAVORY SAUSAGE AND CHEDDAR BREAKFAST CASSEROLE

Serves 6 to 8

This recipe is perfect for using up stale bread since its firm texture stands up to overnight soaking. A casserole stretches expensive ingredients by using them to flavor low cost ingredients so this meal is a good value when you need to feed a holiday crowd.

5 cups (1-inch) cubes sourdough or white bread

1/2 pound loose breakfast sausage, cooked (about 1 cup cooked)

1 cup spinach leaves

8 eggs

2 cups milk

2 cloves garlic, finely chopped

1/2 teaspoon salt

1/2 teaspoon black pepper

1/2 teaspoon dried sage

1 cup grated cheddar cheese

Layer bread, sausage and spinach in an 8-inch baking dish. In a medium bowl, whisk together eggs, milk, garlic, salt, pepper and sage then pour over contents in baking dish. Sprinkle with cheese, cover and chill for at least 2 hours, or preferably overnight.

Preheat oven to 350°F. Uncover dish and bake until cooked through and golden brown, 50 to 60 minutes. Set aside to let rest for 10 minutes then serve.

CRANBERRY BANANA OAT BREAD

Serves 9

Moist and dense in texture, this bread is easy to prepare and very adaptable, accommodating your choice of chopped nuts or dried fruit in place of the cranberries. For a delicious alternative grain version, try our Cranberry Banana Quinoa Bread.

1 1/4 cup all-purpose flour

3/4 cup quick-cooking rolled oats

1 tablespoon baking powder

1/2 teaspoon fine sea salt

1 1/4 cup ripe mashed banana pulp (about 3 bananas)

2 large eggs

1/3 cup nondairy margarine, melted and cooled or canola oil

1/2 cup sugar

1/2 cup dried cranberries

Preheat the oven to 350°F. Lightly oil an 9x5-inch loaf pan with a small amount of margarine.

Whisk together flour, oats, baking powder and salt in a large bowl. Set aside. Whisk bananas, eggs and margarine together in a separate bowl. Add sugar, cranberries, and lemon juice; mix until blended. Gently stir the banana mixture into the flour mixture until just combined. Do not over mix the batter.

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5 Easy Ways to Live Longer

According to the American Heart Association, many people experience no symptoms before having a heart attack or stroke.

A series of simple screening tests by trained experts in cardiovascular disease can identify problems before symptoms develop, preventing issues down the road. *The cost is low. The tests are simple and fast. Aren't you worth it?*

1 Carotid Artery Evaluation

Strokes rank 3rd among all causes of death behind diseases of the heart and cancer. To assess your risk for stroke, an ultrasound probe is placed on your neck to screen for blockages in your carotid arteries which supply blood to the brain. This is also a marker of heart attack risk. **15 minutes, $40**

2 Cardiac Function Evaluation

To analyze cardiac function and calculate your Ejection Fraction (the amount of blood your heart is able to pump), an ultrasound probe will be positioned at various locations on your chest. **15 minutes, $40**

3 Abdominal Aorta Evaluation

Most abdominal aneurysms are asymptomatic. They're the 10th leading cause of death in males over 55. To screen for aneurysm, an ultrasound probe is used to analyze your abdominal aorta. **15 minutes, $40**

4 Ankle/Brachial Index

Blood pressures are obtained from your legs and arms to screen for peripheral artery disease. It not only assesses circulation to the legs, but also is a marker of heart attack risk. **15 minutes, $40**

5 Cardiac Calcium Score

Coronary plaque can build up silently for years, and if untreated can cause blockages and heart attacks. This test measures the calcified plaque in the coronaries and is an indirect measure of the total amount of plaque in the coronaries. A multi-slice CT scanner takes a series of pictures of your heart in just a few seconds. **15 minutes, $99**

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Through the Years

Heart disease strikes young and old alike, taking many shapes and forms.
At Oklahoma Heart Institute, our specialists treat heart problems that occur through all ages.
From a rhythm disturbance in young athletes, to heart attacks in the middle aged,
to valve replacement in the elderly, the doctors of OHI have the technology
and expertise to care for you all through your years.

For a continuum of heart care that stands the test of time, trust the doctors of
Oklahoma Heart Institute.

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