Oklahoma Heart Institute

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Coronary Stents That Dissolve

Prime Time for Coronary Artery CT in the ER

Reducing Stroke Risk in Atrial Fibrillation

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Oklahoma Heart Institute

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1120 Utica Ave., Tulsa, OK 74104
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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

The field of Cardiovascular Medicine continues to enjoy a renaissance period with exciting new technologies entering the clinical arena in what is an almost continuous basis. These new treatments provide earlier detection of cardiovascular disease and better treatment options for patients. The trend is clearly to provide better care in a much less invasive manner.

This year's OHI winter magazine is designed to highlight these newer technologies. Articles highlight the new dissolving coronary stents. New options for the prevention of stroke in patients with atrial fibrillation are now available that do not require long-term anticoagulation. Cardiac CT to aid in the diagnosis of acute coronary syndromes in the emergency setting are now becoming common place. Transcatheter valve therapies are now routinely done at Oklahoma Heart Institute, and the age of left ventricular assist devices for the treatment of advanced heart failure is starting to become prime time. The excitement, enthusiasm and hope that these new therapies bring to both healthcare providers and patients is quite encouraging.

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

Sincerely,

Wayne Leimbach

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

ON THE COVER
Happy Holidays from our hearts to yours! "Oklahoma Heart Institute — The Hospital" by Tulsa artist Christopher Westfall.

Coronary Stents That Dissolve

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

This summer, the United States FDA (Food and Drug Administration) approved the Absorb Bioresorbable Vascular Scaffold (BVS) system. The Absorb stent is the first fully bioresorbable percutaneous coronary intervention technology.

Stents are traditionally made of metal. They are mounted on a balloon catheter, which is advanced across blockages in the blood vessels to the heart. The blockages limit the amount of blood flow to the heart muscle. This situation often produces symptoms of chest discomfort, called angina.

The delivery balloon is inflated, which opens and expands the stent. The stent props the vessel lumen open, which restores blood flow to the heart muscle downstream. Over the next 6 months, the vessel heals and the stent becomes covered with an endothelial lining. The metal stent remains a permanent part of the vessel wall.

The new Absorb Bioresorbable Stent is made of poly (L-lactide), which is a naturally dissolving material similar to re-absorbable sutures (Figure 1). The Absorb stent, when first placed, has the radial strength to expand the vessel lumen and push aside the blockage material (plaque). The radial strength of the Absorb stent is maintained for six months while the vessel heals. After the vessel has healed in an open position, the stent material is metabolized to water and carbon dioxide, and after three years, the stent is gone (Figure 2). The Absorb stent is a drug-eluting stent, which has a low restenosis rate, like the currently used metal stents that are drug-eluting.

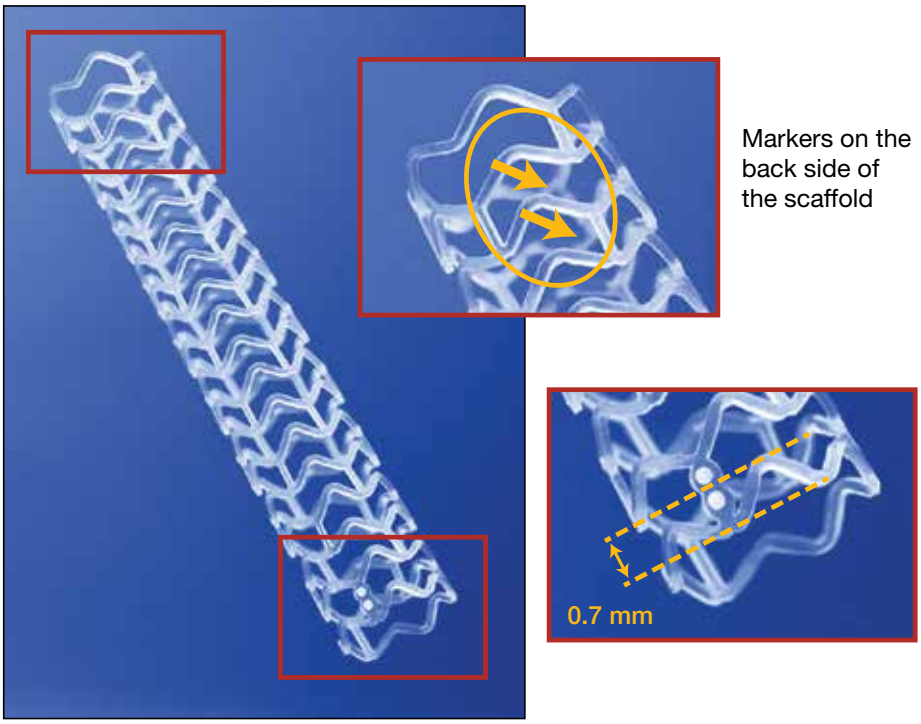
The major difference between the current metal drug-eluting stents as compared to the Absorb resorbable drug-eluting stent is that after three years, the stent is gone. Why would this be beneficial? A major reason is that once the stent has been re-absorbed, the normal vasomotion of the coronary artery is restored. The vessel once again can dilate or constrict depending on the blood flow needs to the heart muscle downstream. With current metal stents, the vessel wall becomes attached to the stent and the stent keeps the vessel at a fixed size.

In addition, if the opening of side branches becomes partially covered by the stent struts (called jailed side branches), when the stent dissolves, the side branch openings become fully open again for both normal blood flow and for vascular access, should the person develop a new blockage in the side branch years later that needs to be fixed.

Some have asked, why not use the absorbable stent in all patients? There are several reasons, including the Absorb stent does not come in all the sizes available that exist for metal stents. The Absorb stent is not as easy to get to the stenosis

Figure 1

Bioresorbable Polymer



Note: The struts are not visible under fluoroscopy. Photos taken and data on file at Abbott Vascular.

Figure 2

Clinical Evidence Available Along the Entire Continuum of Therapy

0 months	6 months	1 year	2 years	3 years	5 years
>98% Procedural Success	Healing Comparable to Best DES	Efficacy & Safety Comparable to DES	Event Rates Comparable to DES	Low Event Rates Long Term	Stable Lumen Area (OCT), Restoration of Vasomotor Function
• REPARA[1] • GABI-R[2] • UK Registry[3] • France Absorb[4]	• TROFI II[5] • ESTROFA-BVS[6]	• ABSORB III[7] • ABSORB Japan[8] • ABSORB China[9] • ABSORB-FIRST[10] • GHOST-EU[11]	• ABSORB II[12] • ASSURE[13]	• ABSORB Extend[14]	• ABSORB Cohort B[15]

Baseline | 6 months | 2 years | 5 years

Vessel healing over time correlates to clinical data

Cohort B OCT Images - courtesy of RJ van Geuns, Erasmus Medical Center, Netherlands

[1]Hernandez, F. REPARA, EuroPCR 2016
[2]Hamm, C. GABI-R, EuroPCR 2016
[3]J. Hill, UK Registry, EuroPCR 2016
[4]Koning, France Absorb, EuroPCR 2016
[5]Serruys, P.W. TROFI II, ESC2015
[6]De La Torre Hernandez, J., ESTROFA BVS, EuroPCR 2015
[7]Kereiakes, D., ABSORB III, TCT 2015
[8]Kimura, T., ABSORB Japan, ESC 2015
[9]Gao, R., ABSORB China, TCT 2015
[10]Seth, A., ABSORB FIRST, TCT 2015
[11]Capadanno, D., GHOST-EU Propensity Matched Analysis, TCT 2015
[12]Chevalier, B., ABSORB II, TCT 2015
[13]Schwencke, C., ASSURE, TCT 2015
[14]Wu, C.J., ABSORB EXTEND, TCT AP 2015
[15]Serruys, P.W., ABSORB Cohort B, TCT 2015

or across the stenosis as compared to the lower profile metal stents. In addition, heavily calcified blockages are not optimal for the Absorb stent.

But for patients with suitable vessels and suitable vessel sizes, we are very pleased with the outcomes of the Absorb Bioresorbable Scaffold. The world-wide experience with the Absorb stent consists of more than 150,000 patients. There have been 12 randomized clinical trials comparing it to standard interventional therapies. There are 20 registries looking at outcomes and over 30,000 patients have been studied.

At Oklahoma Heart Institute, we were involved in some of the clinical trials that led to the approval of the Absorb Bioresorbable Scaffold. We were pleased to be the first center in Northeastern Oklahoma to offer this new coronary stent.

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. 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 serves as Clinical Associate Professor of Medicine at the University of Oklahoma College of Medicine-Tulsa.

Figure 3

ABSORB™ Potential Benefits

- Restoration of vasomotion[1]
- Late lumen gain[1]
- Unjail side branches[2]
- Plaque regression[1]
- Non-invasive imaging[3]
- Avoid permanent complications of future devices[4]

[1]Serruys, P, 5 Yr Cohort B Imaging Results, TCT 2015

[2]Onuma, Yoshinobu; Garcia-Garcia, Hector M.; Koolen, Jacques; Muramatsu, Takashi; Nakatani, Shimpei; et al. Journal of the American College of Cardiology, suppl. 1 62.18 (Oct 29, 2013): B12.

[3]Tanabe, K et al, MSCT of Absorb vs Metallic DES: Absorb Japan Trial, TCT 2015

[4]Yamaji, K., et al. Very Long-Term Clinical and Angiographic Outcome After Coronary Bare Metal Stent Implantation, Circ Cardiovasc Interv. 2010: DOI; 10.1161/CIRCINTERVENTIONS.110.958249

Prime Time for Coronary Artery CT in the Emergency Room

By Victor Cheng, MD, Director, Cardiovascular CT, Oklahoma Heart Institute

Figure 1

Face-on view of the cardiac CT scanner at Oklahoma Heart Institute

Chest pain serious enough to prompt medical attention in the emergency room frequently creates a diagnostic dilemma for both the clinician and the patient. Emergency room physicians want to catch every heart attack or impending heart attack (together these are termed "acute coronary syndrome" and abbreviated ACS in medical literature) from coronary artery disease (CAD). Initial assessment with interview, exam, electrocardiogram, and blood testing finds clear evidence of heart attack in only a small fraction of patients, and in the remainder, often cannot reliably differentiate between those with and without ACS. This leads to hospitalizing many patients without symptomatic heart disease out of caution. Meanwhile, the patient struggles with balancing the concern of not knowing if he or she is truly at risk for heart attack and the desire to avoid an unneeded stay in the hospital.

In 2005, a potentially rapid and comprehensive solution to this dilemma materialized when coronary artery visualization by CT scanning dramatically improved. In a test known as coronary CT angiography (CTA), contrast (an iodine-based liquid that produces a bright signal in blood vessels) is injected into an arm intravenous catheter. Once contrast fills the coronary arteries, the scanner images the heart during a single breath-hold. Using cues from the patient's heart rhythm, a motionless, 3-dimensional image of the entire heart is generated, and disease within the coronary arteries can then be seen. Numerous studies performed from 2005-2008 verified CTA to be highly accurate when compared to the gold standard of invasive

Figure 2a

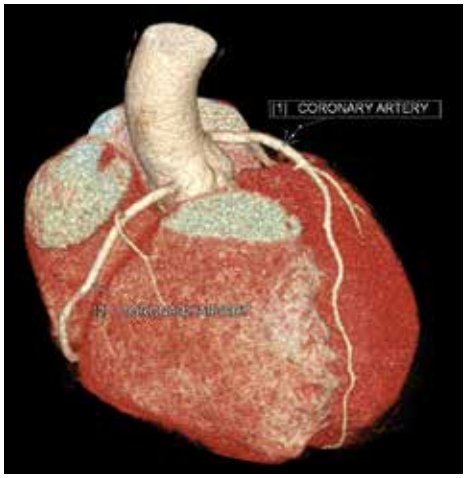
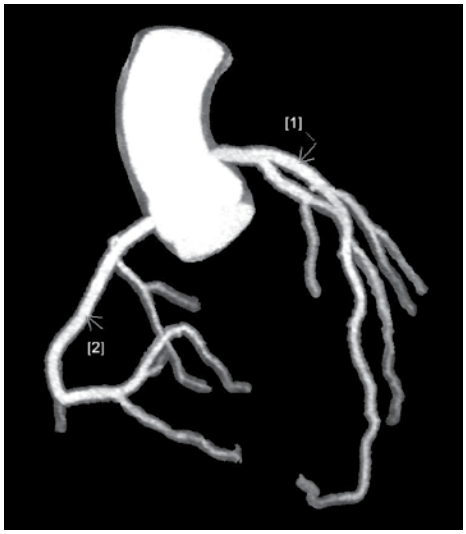


Figure 2b



Three-dimensional displays of normal coronary arteries from a patient with chest pain in the emergency room. The left anterior descending artery and right coronary artery are labeled [1] and [2].

coronary artery catheterization.[1-5] CTA reliably showed if a coronary artery is normal, has minimal/mild disease, or has severe blockage.

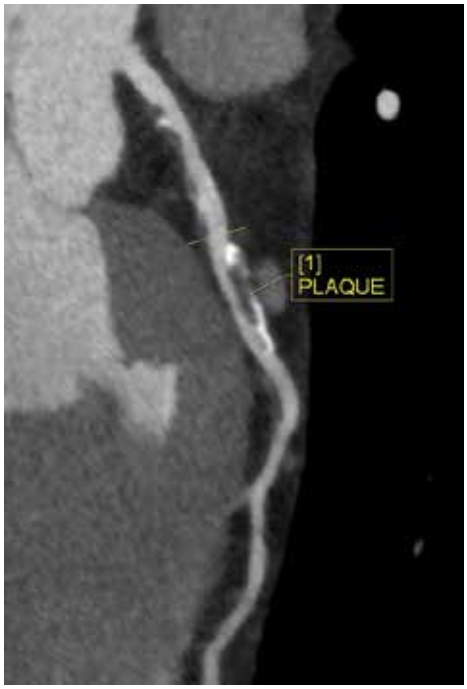
Publication of 3 randomized controlled-trials named CT-STAT, ROMICAT 2, and ACRIN-PA in 2011-12 validated coronary CTA for chest pain evaluation in the emergency room in patients without coronary artery bypass graft surgery or coronary artery stent(s).[6-8] These trials showed several important points:

1. At a well-prepared medical center, the time from deciding to proceed with coronary CTA to getting CTA results is easily less than 2 hours.
2. Approximately half of the patients have normal coronary arteries or minimal CAD.
3. Compared to usual care, CTA helped send many more patients home safely from the emergency room and reduced overall hospitalization time.
4. And most importantly, no cases of ACS were missed when patients were sent home after CTA successfully excluded obstructive CAD. There are other potential benefits for the patient. Knowing whether any disease is present in the coronary arteries may reduce anxiety. Coronary CTA occasionally identifies non-heart reasons for chest pain. Finding little or no CAD may negate the need for additional heart testing and follow-up consultation with a cardiologist.

In 2010, the American College of Cardiology and the American Heart Association agreed that coronary CTA is appropriate when the emergency room clinician remains unsure about ACS after initial evaluation.[9] This was reaffirmed in an updated 2015 joint statement specifically addressing chest pain evaluation in the emergency department from the American College of Cardiology, American Heart Association, and 12 other professional medical organizations.[10]

In the summer of 2013, we made dramatic personnel and facility upgrades to the Oklahoma Heart Institute heart CT program, including installation of a state-of-the-art, 128-slice dual-source scanner. Since then, we have been collaborating with the Hillcrest Medical Center emergency medicine team in using coronary CTA for patients without coronary artery stent(s) or bypass surgery seeking care for chest pain. Thus far outcomes have been outstanding. From June of 2013 through July of 2016, 390 emergency room patients with chest pain underwent coronary CTA. When our coronary CTA found no evidence of obstructive CAD, none of the patients suffered ACS in the following 30 days. When coronary CTA found obstructive CAD, all patients were hospitalized, and 67% were eventually diagnosed with ACS and treated with some combination of medications, coronary artery angioplasty and stenting or, in a few cases, open heart surgery. What does all this mean? Our experience essentially replicated results from the landmark 2008 trials. Coronary CTA at OHI does not miss heart attack or impending heart attack from the emergency room and capably identifies patients in whom coronary artery disease is likely causing chest pain.

Figure 3



Large plaque causing severe obstruction (labeled "[1] PLAQUE") in a major coronary artery in a patient with chest pain in the emergency room, confirming the diagnosis of acute coronary syndrome.

For patients with chest pain and uncertain probability for ACS in the emergency room, coronary CTA is the only noninvasive test able to clearly separate those at-risk from those safe-from-risk, while avoiding hospitalization or prolonged patient monitoring. This efficacy places coronary CTA in a strong position as demand for achieving medical diagnoses in an efficient, rapid, and resource-conserving manner continues to rise from policy makers, insurers, and patients. For forward-thinking emergency and cardiac medicine clinicians, prime time for coronary CTA in the emergency room has come..

Dr. Cheng is a specialist in noninvasive heart and vascular imaging at Oklahoma Heart Institute, particularly in cardiac computed tomography (CT), a topic on which he has published numerous original research publications addressing quality, clinical use, and novel applications.

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Coronary CTA at OHI does not miss heart attack or impending heart attack from the emergency room and capably identifies patients in whom coronary artery disease is likely causing chest pain.

Reduction of Stroke Risk in Atrial Fibrillation: The Dawning of a New Era

By David A. Sandler, MD, FACC, FHRS

Atrial fibrillation (AF) is a well-established cause of stroke, leading to significant disability, mortality and cost. Until recently, the only option for stroke prevention was an inconvenient pill to thin the blood. Over the last decade the options have increased tremendously with multiple new medications entering the field. Last year, a new era arrived with the FDA approval of an implantable device to reduce stroke in AF patients by occluding the left atrial appendage. This article will review the history of stroke prevention in AF and describe how LAA occlusion could revolutionize the way we manage AF patients.

Last year, a new era arrived with the FDA approval of an implantable device to reduce stroke in AF patients by occluding the left atrial appendage.

Etiology of Stroke in Atrial Fibrillation

The left atrial appendage (LAA) is an outpouching cul-de-sac of the left atrium (Figure 1). Unlike the smooth left atrial wall, the LAA has a rough surface containing multiple trabeculations — forming an ideal location for slow blood flow to form a clot. Autopsy and surgical observations since the 1930s have implicated the LAA as a source of embolic stroke. More recent data, including evidence from transesophageal echocardiography (TEE), suggests that over 90% of AF-related strokes are caused by emboli originating in the LAA (Figure 1).

The Warfarin Era

In order to reduce thrombus formation in the stagnant blood flow of the LAA, thinning the blood is a logical approach. In the 1980s, investigators began using warfarin to help reduce stroke in AF. This agent, initially used as a rodenticide, was found to be incredibly effective. Multiple clinical trials demonstrated an unprecedented two-third stroke reduction in AF patients. The downsides, of course, were numerous: bleed-

Figure 1

Illustration of the left atrial appendage (left) and a transesophageal echocardiogram (TEE) demonstrating a thrombus within the left atrial appendage (right)

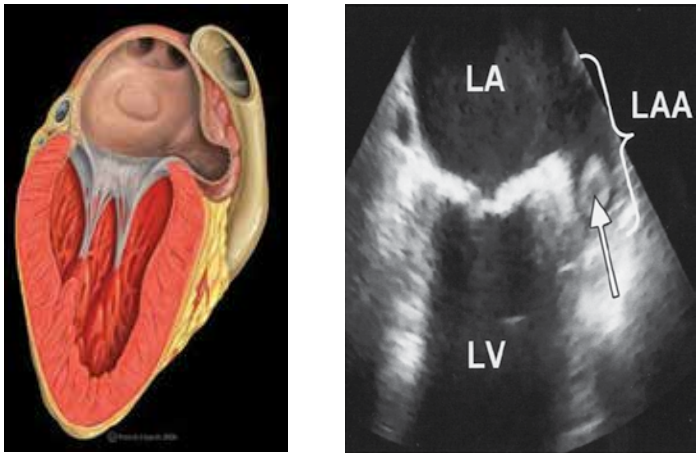


Figure 2

Watchman left atrial occluder placed across the interatrial septum into the left atrial appendage

ing, frequent blood draws, dietary restrictions. Nonetheless, owing to its tremendous efficacy (and lack of an alternative), warfarin remained the standard of care for over three decades.

Novel Oral Anticoagulation

Scientists feverishly sought more convenient, safer medications to replace warfarin. In 2009, the RE-LY Trial was published, opening a new era in AF stroke prevention. A new agent, dabigatran (Pradaxa), was found to have lower rates of stroke and similar rates of major bleeding. Over the subsequent years, 3 new agents acquired FDA approval: rivaroxaban (Xarelto), apixaban (Eliquis) and edoxaban (Savaysa). Each agent has advantages and disadvantages over its competitors, which will not be covered in this article. As a group, the novel oral anticoagulants (NOACs) have demonstrated significant improvements over warfarin, including: easier dosing, no need for routine blood testing and no dietary restrictions.

Despite these advantages, one fundamental problem exists. Namely, blood thinners cause bleeding. In fact, a recent study demonstrated that by two years, half of warfarin patients and a quarter of NOAC patients had discontinued their blood thinner for some reason.

LAA Occlusion

So why thin the entire blood pool when the goal is reducing clot formation in only one small portion of the heart? This is why surgeons first began ligating the LAA in the 1930s. While surgical ligation, obliteration, and removal are still viable options for patients in need of cardiac surgery, for the vast majority of AF patients, the procedure poses unnecessary risk. A percutaneous approach to LAA occlusion is therefore an obvious target for investigators interested in reducing AF-related stroke without exposing the patients to the risk of blood thinners.

The Watchman device is a parachute-shaped device that can be deployed within the LAA with a percutaneous procedure often lasting less than an hour (Figure 2). The device enters the body from a catheter placed in the right femoral vein. The device is advanced from the right atrium through a small hole in the septum and into the left atrium. For the first 6 weeks, the patient is placed on warfarin and aspirin to allow the body to grow a thin layer of tissue over the device.

Early data of the Watchman device published in the PROTECT-AF Trial in 2009, demonstrated similar results to standard warfarin therapy. The benefits of Watchman became clear, however, when the patients were followed

Table 1
Protect AF:
4-year results demonstrating fewer hemorrhagic strokes, disabling strokes, and mortality

Watchman superior to Control: primary efficacy, CV death, hemorrhagic stroke and all-cause mortality

	Device group rate	Control group rate	Hazard ratio WATCHMAN/ warfarin (95% CI)	P
Primary efficacy	2.3	3.8	0.61 (0.38, 0.97)	0.0348
CV death	1.0	2.4	0.40 (0.21, 0.75)	0.0045
All stroke	1.5	2.2	0.70 (0.39, 1.26)	0.2244
Hemorrhagic stroke	0.2	1.1	0.16 (0.04, 0.51)	0.0049
Ischemic stroke	1.4	1.1	1.30 (0.64, 2.84)	0.4921
Disabling stroke	0.5	1.2	0.37 (0.15, 1.00)	
All-cause mortality	3.2	4.8	0.66 (0.45, 0.98)	0.0379
Primary safety	3.6	3.1	1.21 (0.78, 1.94)	0.4051

Table 2
$CHADS_2$ and CHA_2DS_2VASc stroke prediction models.
Add 1 or 2 points for each risk factor. Risk of stroke is increased for sum of all points.

Risk Factors for Stroke in AF

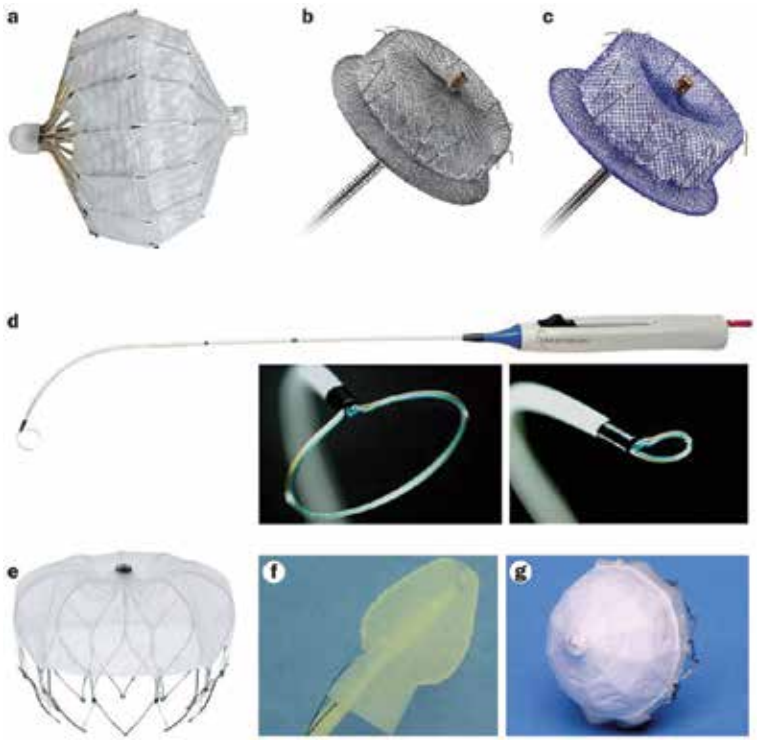
$CHADS_2$	
Congestive heart failure	1
Hypertension	1
Age > 75	1
Diabetes	1
Stroke	2

$CHAD_2DS_2VASc$	
Congestive heart failure	1
Hypertension	1
Age > 75	2
Diabetes	1
Stroke / TIA	2
Vascular disease	1
Age > 65	1
Sex (female gender)	1

The Watchman device is a parachute-shaped device that can be deployed within the LAA with a percutaneous procedure often lasting less than an hour.

Figure 3

Various transcatheter mechanical left atrial appendage occlusion devices



Yu, CM et al. Nat. Rev. Cardiol. 2013:10;707–722

Watchman for LAA occlusion has been shown to reduce the risk of stroke without the risk of long-term anticoagulation.

out to 4 years (Table 1, Reference 1). The patients implanted with the Watchman device were less likely to have a major stroke, a disabling stroke or an intracranial bleed. Patients implanted with the Watchman had less major bleeding and lower mortality than those prescribed warfarin.

The 4-year Watchman data have tremendous implications. This prospective, randomized study conclusively demonstrates for the first time that occlusion of the LAA reduces stroke, confirming our suspicions for nearly a century. Next, the study demonstrates that patients with AF don't have to balance risk of stroke with risk of bleeding from blood-thinners: they can have stroke reduction without blood thinners. Lastly, in the era of cost containment, economic assessment performed on this group of patients shows that the Watchman device is both clinically effective and cost-effective (cheaper than NOACs) by 5 years (Reference 2).

Indications for Watchman

In February of 2016, Center for Medicare and Medicaid Services (CMS) published its coverage decision for Watchman which defines the candidates for this procedure:

The patient must have a high risk of stroke ($CHADS_2 \geq 2$ or $CHA_2DS_2VASc \geq 3$) (Table 2)

The patient must have suitability for short-term warfarin but deemed unable to take long term oral anticoagulation

A formal shared decision making interaction with an independent non-interventional physician using an evidence-based decision tool on oral anticoagulation

While significant debate remains in the definitions, this framework helps identify patients who are likely to gain the greatest benefit from LAA occlusion. In order to benefit from LAA occlusion one must have significant risk of stroke. Patients with $CHADS_2 \geq 2$ or $CHA_2DS_2VASc \geq 3$ are anticipated to have stroke risks of approximately 4% per year. In order to safely deploy the device, the patient must be able to tolerate warfarin for 6 weeks (this is why patients who are too high risk for anticoagulation for even short periods are not candidates for this therapy). The shared decision making process is in place to ensure that the patient has been able to discuss personal wishes and concerns with a physician separated from the procedure.

Conclusion

A new era in AF stroke prevention has certainly arrived. Just 10 years ago, patients with AF had only one option for stroke prevention: warfarin. The past decade has brought us 4 new agents to reduce stroke with significant advantages including convenience, superior efficacy and superior safety. Today, we have yet another tool – Watchman for LAA occlusion. This device has been shown to reduce the risk of stroke without the risk of long-term anticoagulation.

What's next? Multiple LAA occlusion devices are in clinical trial. In the next decade, we will have a plethora of options for these patients (Figure 3). Furthermore, ongoing clinical trials will likely lead to expansion of indications.

Dr. Sandler is a cardiologist at Oklahoma Heart Institute with subspecialty expertise in electrophysiology, complex ablation, and atrial fibrillation management. He is Director of Electrophysiology at Oklahoma Heart Institute Hospital.

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- Thyroid
- Hypertension
- Other Endocrine Problems

Specialty Clinics
- Advanced Center for Atrial Fibrillation
- Dysrhythmia and Pacer Clinic
- Hypertension Clinic
- Resistant Hypertension Clinic
- Adolescent and Adult Congenital Heart Clinic
- Lipid and Wellness Clinic
- Heart Failure Clinic
- Same Day Appointment Clinic
- Pre-Operative Clinic
- Center for the Treatment of Venous Disease
- Sleep Care
- Center for Peripheral Arterial Disease
- The Valve Clinic

Cardiovascular Surgery

CARDIAC SURGERY
- Coronary Artery Bypass
- Surgical Aortic Valve Replacement
- Transcatheter Aortic Valve Replacement with TAVR Team
- Mitral and Tricuspid Valve Repair and Replacement
- Surgical Treatment of Atrial Fibrillation: “Mini-Maze”, Full Maze, Left Atrial Appendage Ligation
- Cardiac Tumor Resection

THORACIC NON-CARDIAC SURGERY
- VATS (Video Assisted Thoracoscopy Surgery) for Biopsy and Treatment
- Minimally Invasive and Open Techniques for Diagnosis and Staging of Lung and Nonpulmonary Cancer in the Chest
- Minimally Invasive and Open Techniques for Therapeutic Lung Cancer Resection
- Surgical Treatment of Esophageal Cancer and Benign Esophageal Conditions

VASCULAR SURGERY
- Endovascular and Open Treatment of Aortic Aneurysms: Abdominal and Thoracic Diagnosis, Surgical, Interventional and Medical Management of Peripheral Arterial Disease (PAD)
- Surgical Treatment of Carotid Occlusive Disease
- Limb Salvage

MEDIASTINAL SURGERY
- Evaluation and Treatment of Mediastinal Masses

THYROID/ENDOCRINE SURGERY
- Full Spectrum of Thyroid Surgery (Total versus Near Total Thyroidectomy)
- Parathyroid Surgery with Intraoperative PTH monitoring
- Recurrent Nerve Monitoring

Oklahoma Heart Institute Hospital
1120 Utica Avenue
Tulsa, OK 74104
P) 918.574.9000

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

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

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

Robert E. Lynch, MD, FACC

Dr. Lynch is a specialist trained in noninvasive and invasive cardiology with a special interest in the prevention of cardiovascular disease. He is former Chief of Cardiology at Hillcrest Medical Center, where he also has served as Chief of Medicine and President of the medical staff. Dr. Lynch is former Co-Director of the Lipid and Wellness Clinic at Oklahoma Heart Institute and Director of the Executive Health Program. Dr. Lynch is also a Clinical Assistant Professor at the University of Oklahoma College of Medicine – Tulsa. He completed his Cardiology Fellowship, as well as his Internal Medicine Internship and Residency, at the University of Oklahoma Health Sciences Center. Dr. Lynch received his medical degree from the University of Oklahoma School of Medicine and his Bachelor of Science degree from the University of Tulsa. Before establishing his practice in Tulsa, he served as Chief of Medicine at the U.S. Army Hospital, Bangkok, Thailand.

Board certified in Internal Medicine and Cardiovascular Disease

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

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 arrhythmia, 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 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 is 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

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 comprehensive 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 for the past four years. 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 included 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, Warren Clinic and Springer Clinic. 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 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 University /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, and board eligible in 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.

Left Ventricular Assist Devices (LVADs) in Management of Heart Failure:

A Tale of the 20th Century

By Mrudula R. Munagala, MD, FACC

Introduction and Epidemiology of heart failure:

Heart failure (HF) is considered to be a global epidemic and poses a significant medical, social and economic burden. Analysis of the National Health and Nutrition Examination Survey (NHANES) 2009 to 2012 showed that an estimated 5.7 million Americans ≥ 20 years of age were diagnosed with heart failure[1]. Prevalence of heart failure is expected to increase by 46% from 2012 to 2030, resulting in >8 million people with heart failure. Furthermore, heart failure remains one of the most common admitting diagnoses in United States and heart failure mortality remains high with 50% of the patients dying within 5 years[1,2&3]. Pharmacotherapy of chronic systolic heart failure with beta blockers, angiotensin converting enzyme (ACE) inhibitors, angiotensin receptor blocking agents (ARB), and aldosterone antagonists have improved survival and quality of life in these patients[4]. Implantable cardioverter defibrillators (ICDs) and cardiac resynchronization therapy in select heart failure patients have demonstrated mortality benefit[5 & 6].

Successful management of acute myocardial infarction and advances in both percutaneous and surgical revascularization has led to improved survival of patients with ischemic heart disease[3&7]. Paradoxically, advances in medical, percutaneous, and surgical treatments of ischemic, congenital, and valvular heart diseases along with an aging population have contributed to the increased prevalence of heart failure. Significant progress has been achieved in rescuing patients after cardiac arrest through the institution of hypothermia (cooling) and in refractory cardiogenic shock with the use of percutaneous circulatory support devices such as an intra-aortic balloon pump, Impella, extracorporeal membrane oxygenation (ECMO), and Tandem Heart. While the mortality of these patients has been reduced, we now face an increasing population of patients with advanced heart failure.

What is an LVAD?

LVADs are mechanical circulatory support devices that unload the left ventricle by emptying the blood from the left ventricle and allowing for better perfusion of end organs. They essentially displace blood from the left ventricle to the aorta via extra-cardiac conduit and thus improve cardiac output.

Evolution of LVADs as destination therapy:

There are limited therapeutic options for terminal heart failure patients. Heart transplant remains the gold standard and is considered to be the best therapeutic option for an end stage heart failure patient who qualifies to receive a transplant. However, it is a scarce resource and is not typically offered to patients above 70 years of age. Some patients may not be candidates for transplantation due to existing co-morbidities. LVADs have evolved as a durable and reliable therapeutic option both as a bridge to transplant (BTT) or as an alternative to transplant defined as Destination Therapy (DT).

LVADs were first approved by Food and Drug Administration (FDA) in 1994 as a bridge to heart transplantation in advanced heart failure patients. The Randomized Evaluation of Mechanical Assistance for the Treatment of Congestive Heart Failure (REMATCH) trial established LVAD therapy as a viable treatment

Figure 1

Pictorial depiction of basic LVAD circuit. LVAD has an inflow cannula which drains blood from left ventricle pump and an outflow conduit that is connected to aorta. Percutaneous lead connects pump to the system controller.

option with a significant survival advantage. Nonetheless, the two year survival rate was only 23% after implantation[8]. The REMATCH clinical trial utilized the HeartMate (HM) XVE, a first generation pulsatile pump that was electrically driven. Utilization of this pump was limited due to the high morbidity and mortality associated with the device. The large pump size and large diameter of the percutaneous lead combined with multiple moving parts contributed to a high complication rate including infections, thromboembolic events, and pump failure requiring device replacement. Subsequently, advances in pump design resulted in the development of continuous flow left ventricular assist devices (CF-LVAD). These are smaller, more reliable and more durable devices with fewer moving parts and allowed implantation in an expanded pool of patients. Patients with CF-LVADs experienced fewer serious adverse events (SAE) and long-term survival improved significantly, leading to the emergence of LVADs as an acceptable long-term therapeutic option[9]. The HeartMate II LVAD became the first CF-LVAD in the United States approved by the FDA in the spring of 2008 as a bridge to transplantation, and in 2010, received approval for implantation as destination therapy. Utilization of these devices has become widespread and approximately 2,500 devices are implanted per year in the United States[10].

WHO GETS IMPLANTED?

The Centers for Medicare and Medicaid Services (CMS) set forth criteria for implantation [11 & 12]

a) Chronic end stage heart failure NYHA functional class IV symptoms

b) Not a candidate for transplant at the time of implantation

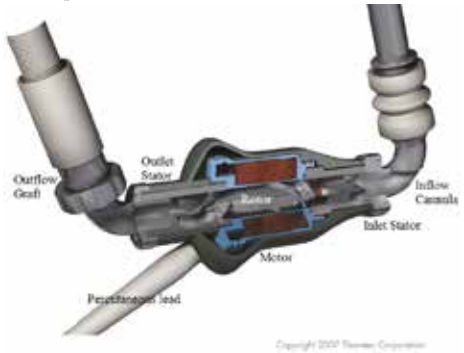

Figure 2

Cross section of LVAD pump demonstrating inlet stator, motor, rotor and outlet stator. Pump s connected to system controller via percutaneous lead. Integrity of percutaneous lead is vital for the normal pump function.

Figure 3

HeartMateII Pocket Controller

c) LVEF < 25%

d) Refractory heart failure symptoms not responding to optimal medical therapy for at least 45 out of last 60 days

e) IABP dependent for 7 days or dependent on intravenous inotropic agents for 14 days

f) Functional limitation with a peak oxygen consumption < 14 ml/kg/mt, unless dependent on either IABP or intravenous inotropes.

In addition, several other clinical, laboratory, echocardiographic and hemodynamic parameters must be reviewed prior to selecting appropriate candidates for implantation. Renal function, lung function, severity of tricuspid regurgitation, right heart function, and nutritional status are some of the important factors to be considered during the process of evaluation. If a patient has contra-indications to systemic anticoagulation, mechanical circulatory support would not be an ideal choice given the known thrombotic and thromboembolic complications[12 & 13]. Each case is reviewed by a multi-disciplinary selection committee composed of heart failure cardiologists, cardiothoracic surgeons, dieticians, social workers, LVAD coordinators, palliative care service and other sub-specialists (pulmonologist, nephrologists and infectious disease specialists). The goal is to assess the treatment options, peri-operative mortality and morbidity burden, adequacy of social support and any psychosocial barriers and expected challenges in achieving a desired quality of life and good long-term survival. The presence of prosthetic valves, severity of aortic regurgitation and prior cardiac or thoracic surgery history needs to be reviewed as these may all pose additional challenges such as the need for concomitant valve repair or replacement procedures, longer dissection times and longer cardio pulmonary bypass (CPB) time[12&13]. Echocardiographic imaging is performed to assess for any associated valvular pathology or atrial septal defects or patent foramen ovale (PFO) and address these at the time of the implantation[11 &13]. Appropriate patient selection is the key for quality outcomes.

Management and complications of LVAD:

After the LVAD implantation, patients are transferred to the intensive care unit (ICU) and careful monitoring of hemodynamic parameters, clinical parameters, urine output, and chest tube output and hepatic and renal functional panels, electrolytes, hemoglobin, hematocrit and platelets are monitored. Echocardiography may be used generously to assess for any complication or to guide management. Major post-operative complications are bleeding, tamponade and RV failure [12, 13 &14]. These complications may require patient to return to operating room, increased blood product consumption, right ventricular assist device (RVAD)[15] placement or prolonged use of inotropic therapy and likely to prolong ICU stay[14]. Systemic anticoagulation is necessary to prevent thromboembolic complications in LVAD patients. Predominant complications of LVAD are either infection or hematologic related issues. In the modern era of CF-LVADs, device failure is uncommon.[10] Long-term management of LVAD centers on preventing these complications. Clinical and laboratory monitoring is essential for early diagnosis and addressing them in a timely manner.

Post-operatively, LVAD patients may encounter complications similar to that of any post-cardiac surgery patient and some of the complications are specific to LVAD. Common complications that are seen in LVAD patients are

1) Bleeding
2) Right ventricular failure
3) Infection (device related and non-device related)
4) Pump thrombosis
5) Stroke (ischemic and/or hemorrhagic)
6) Thromboembolic complications
7) Pump failure (uncommon in CF-LVADs)
8) Aortic regurgitation

Patients with LVAD are more susceptible to infection and therefore appropriate care of driveline exit site is very important. Immobilization of driveline exit site and avoidance of trauma to driveline are essential to prevent the disruption of tissue growth. Patients and caregivers should be instructed on the sterile technique and proper care of the driveline exit site. Antiplatelet therapy with aspirin and anticoagulation with Coumadin is the standard therapy used in patients with LVAD. However, anticoagulation therapy may need to be tailored to each patient, balancing the risk of thrombosis and bleeding to reduce morbidity and mortality. Patients with LVADs are more prone to bleeding complications due to increased shear stress leading to degradation of von Willebrand factor (vWF), increased occurrence of angiodysplastic lesions due to non-pulsatile nature of the flow, and use of anticoagulation and antiplatelet therapy. Incidence of bleeding at a rate of 8-23% is reported by one year, following a 30-day post-operative period after the implantation of the device[16& 17]. Gastrointestinal bleeding is a well-recognized complication in patients with CF-LVADs.

Pump thrombosis is a life threatening complication and is associated with high mortality. An abrupt increase in the incidence of pump thrombosis was noted since 2011[18]. Routine monitoring of lactate dehydrogenase (LDH) is recommended to facilitate early detection and management of hemolysis, pump thrombosis and associated thromboembolic risk[19]. A multidimensional approach is needed in identifying and addressing the complications. Any underlying patient related factors, device or clinical management related issues contributing to the development of complications need to be probed and addressed.

Introduction of CF-LVADs changed the dynamics of long term circulatory support in patients with advanced heart failure and opened doors for reliable and durable long term circulatory support as an alternative to heart transplant in patients who are not candidates or suboptimal candidates for transplant. The seventh annual report of Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) revealed

that 50% of device implants are implanted as DT. Survival of patients with continuous flow devices that are in clinical practice is consistently superior and reported survival rate at 1 and 2 year intervals is 80% and 70% respectively. Shah et al. reported that since introduction of CF-LVADs in 2008, sharp declines in 30 day mortality, in-hospital mortality and average length of stay are noted[20]. Bleeding and thromboembolic complications remain of concern, but infectious complications and pump failure has significantly improved with these devices.

Third generation LVADs were developed to address some of the fore mentioned complications. HeartWare LVAD (HVAD) is a third generation device that is a centrifugal pump and uses hydrodynamic levitation along with magnetic levitation for suspension. This is a smaller device and allows implantation in the pericardial cavity and does not need creation of a preperitoneal pocket[21]. The HeartMate 3 left ventricular assist device is a centrifugal flow pump that is a magnetically levitated with no bearings and has wide blood-flow paths. Additionally, it allows artificial pulse that may avoid blood stasis within the left ventricle and more consistent opening of the aortic valve. Six month results from Conformité Européenne (CE) mark study demonstrated superior 30 day and 6 month survival rates of 98% and 92% respectively with a favorable adverse event profile [22]. Currently, it is being tested in a prospective, multicenter, unblinded randomized control trial in the United States[23]. Development of several newer devices is underway with the goal to abate the associated complications and improve the quality of life along with survival.

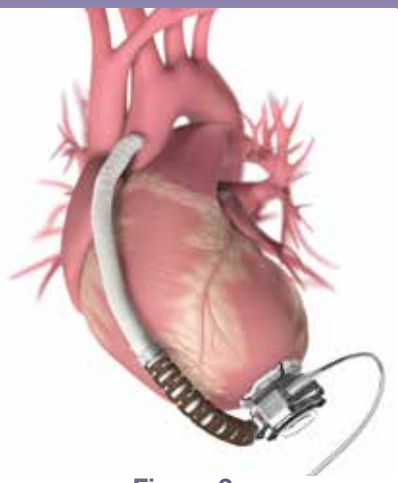

Figure 3

HeartWare LVAD is a third generation LVAD. Smaller size and design of the pump allows implantation of the pump in the pericardial space. This eliminates the need for abdominal surgery for the pump pocket creation and reduces surgical time.

Figure 4

HeartWare LVAD pump showing Impeller

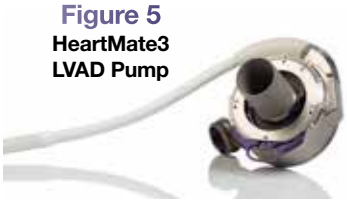

Figure 5

HeartMate3 LVAD Pump

Conclusion:

Prevalence of end stage heart failure patients and an aging population continues to increase and the donor organ supply has plateaued. LVADs have emerged as a reliable therapy in end stage heart disease patients both as a bridge and as an alternative to transplant that not only improve the survival, but significantly enhances the quality of life. The scope of implantation will continue to grow with the technological evolution and clinical and scientific advances in hematology. However, careful patient selection combined with an integrated multidisciplinary approach is needed for durable quality outcomes. The future lies in the development of more physiologic, miniature, biocompatible devices with no percutaneous leads.

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.

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Transcatheter Valve Therapies: State of the Art

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

Introduction

Valvular heart disease is classified as damage to or a disease process affecting any of the four valves of the heart: the aortic, mitral, tricuspid or pulmonary valves. The diseases of these may be congenital (present from birth) or acquired later in life. Valvular heart disease is very common and, in advanced stages, can cause significant symptoms, disability and premature death. Traditionally, open heart surgery to repair or replace diseased heart valves has been the standard of care. However, over the last decade transcatheter valve intervention (performed through a catheter/tube) has been developed as a minimally invasive non-surgical alternative technique. In this article, we will focus on the most common types of acquired valvular heart disease affecting the aortic and mitral valves and the evolution of transcatheter valve therapies used for treatment of these diseases.

Aortic Valve Stenosis

Aortic stenosis (AS) is a disorder that restricts the opening of the main valve of the heart that separates the left ventricle from the aorta. The most common cause of aortic stenosis is degenerative calcific disease of an anatomically normal valve. Aortic stenosis is the most common stenotic cardiac valvular abnormality in the United States (Figure 1).

It is estimated that aortic stenosis affects approximately 5 of every 10,000 adults, with the prevalence increasing with the increasing age of the U.S. population. Severe aortic stenosis will eventually result in severe symptoms of congestive heart failure (shortness of breath, leg swelling, and pulmonary edema), chest pain/angina or syncope (nearly passing out or passing out). Many patients, however, also present with non-specific symptoms, such as decreased exercise tolerance. 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%

Figure 1

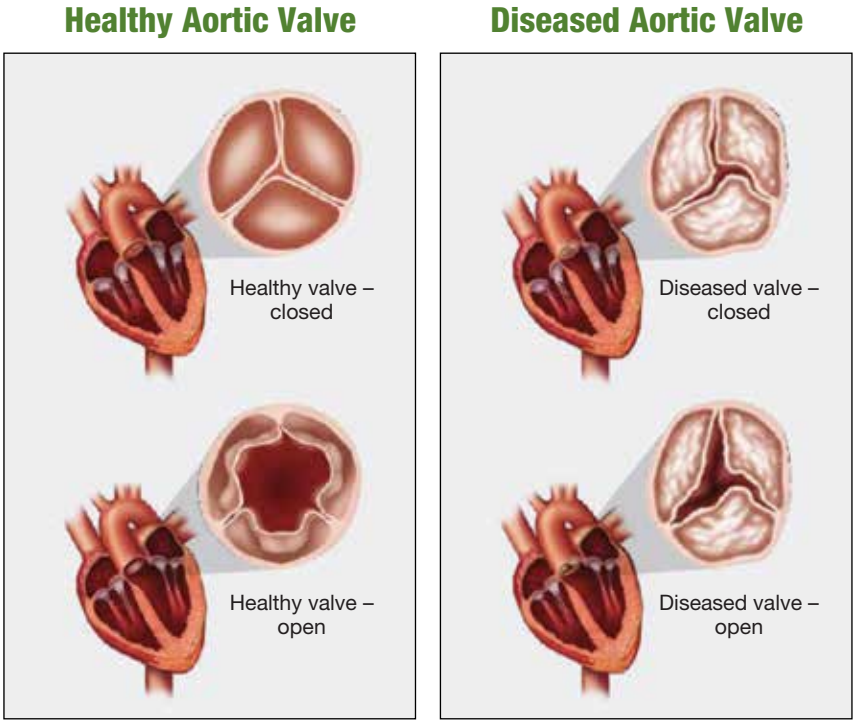
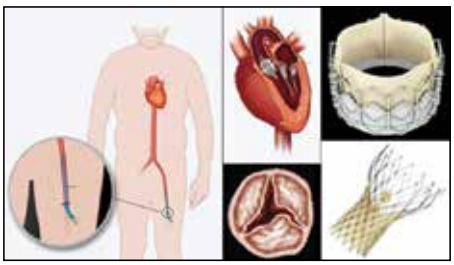


Figure 2

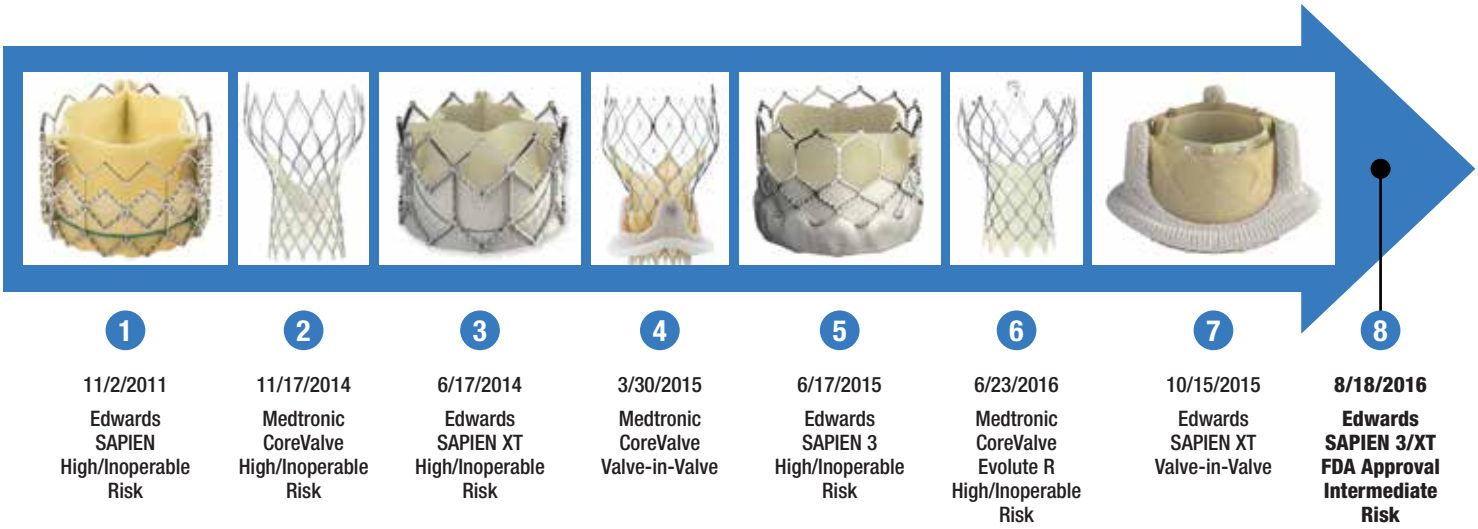


(50% chance of death at 2 years and 80% chance of death at 5 years from untreated aortic stenosis). As such, prompt evaluation for aortic valve replacement is recommended for patients with severe symptomatic aortic stenosis.

Surgical aortic valve replacement is a well-established and effective treatment of severe aortic stenosis, is generally associated with low operative mortality, and has been considered the gold-standard therapy. 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 comorbidities of the patients with severe aortic stenosis, there remains a large number of patients with severe aortic stenosis that go untreated. Indeed, numerous studies over the past decade have

Figure 3

Evolution of TAVR in the U.S.



1	2	3	4	5	6	7	8
11/2/2011	11/17/2014	6/17/2014	3/30/2015	6/17/2015	6/23/2016	10/15/2015	**8/18/2016**
Edwards SAPIEN High/Inoperable Risk	Medtronic CoreValve High/Inoperable Risk	Edwards SAPIEN XT High/Inoperable Risk	Medtronic CoreValve Valve-in-Valve	Edwards SAPIEN 3 High/Inoperable Risk	Medtronic CoreValve Evolute R High/Inoperable Risk	Edwards SAPIEN XT Valve-in-Valve	**Edwards SAPIEN 3/XT FDA Approval Intermediate Risk**

shown that at least 40% of patients with severe aortic stenosis never undergo surgical aortic valve replacement.

Transcatheter Aortic Valve Replacement: Historical Perspective

Transcatheter aortic valve replacement (TAVR) has been developed as a minimally-invasive approach to aortic valve replacement in patients with severe symptomatic aortic stenosis as an alternative to surgical aortic valve replacement (Figure 2). The majority of TAVR cases can be performed percutaneously (without surgery) through the femoral (groin) artery, similar in concept to a cardiac catheterization procedure. TAVR is an established procedure: over 200,000 procedures have been performed in over 65 countries across the world, with an estimated 30,000 TAVR procedures performed in the US in 2015.

The first TAVR procedure was performed in 2002 by a French cardiologist, Dr. Alain Cribier. In 2010, Placement of AoRTic TraNscathetER Valves (PARTNER) Trial was the first multicenter, randomized trial to demonstrate the effectiveness of TAVR using the Edwards Lifesciences SAPIEN valve in patients with severe symptomatic aortic stenosis who were high-risk and inoperable to undergo surgical aortic valve replacement. 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 additon, the 2nd generation Medtronic CoreValve Evolute R porcine self-expanding THV received FDA approval on June 23, 2015. Valve-in-valve TAVR was also approved in 2015 for the use of a THV to replace a failed bioprosthetic surgical valve in patients who are high risk for redo surgical aortic valve replacement (Figure 3).

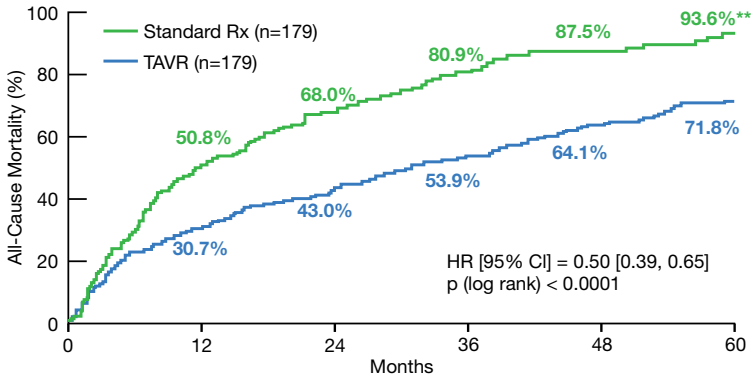
Most recently on August 18, 2016 the FDA expanded the indications for both the Edwards Lifesciences' Sapien 3 and Sapien XT transcatheter heart valves for the treatment of patients who have been determined by a heart team to be at intermediate risk (greater than three percent risk of dying within 30 days following surgery) for open-heart surgery (Figure 3). Approval was based upon the PARTNER II and IIa data which demonstrated TAVR to be safe and effective in the intermediate risk population.

Numerous major trials of TAVR performed across the United States and the world have established the safety and effectiveness of TAVR for the treatment of high-risk and intermediate-risk patients with severe symptomatic AS. These studies have shown that TAVR is superior to

Figure 4a

All-Cause Mortality (ITT)

Crossover Patients Censored at Crossover



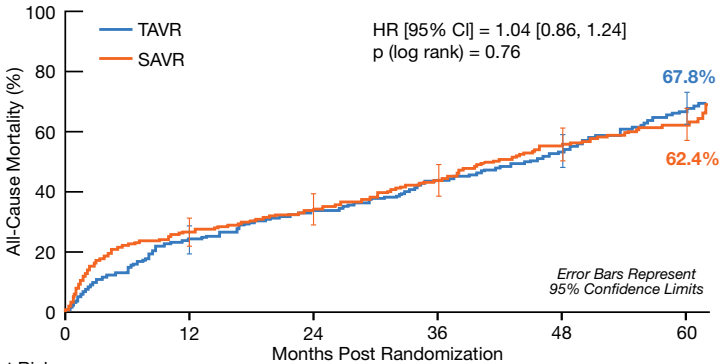
* In an age and gender matched US population without comorbidities, the mortality at 5 years is 40.5%.

** Only 1 standard Rx patient was alive at 5 years who didn't crossover to TAVR or had SAVR (out of protocol)

Figure 4b

All-Cause Mortality (ITT)

All Patients



No. at Risk

TAVR	343	262	223	191	154	61
SAVR	351	236	210	174	131	64

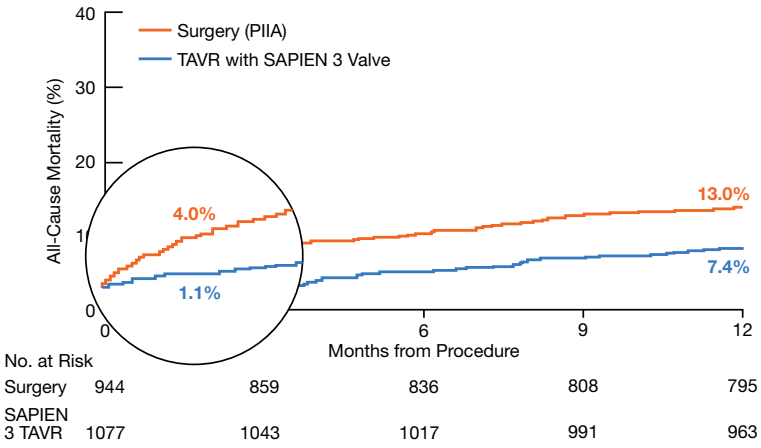
medical therapy for high-risk AS (22% reduction in mortality at 5 years, Figure 4a), equivalent to surgery in high-risk patients for mortality at 5 years (Figure 4b), and superior to surgery in intermediate risk patients (5.6% lower mortality and 3.4% lower stroke at 1 year, Figure 4c,d). TAVR has also been shown to improve survival, quality of life and hospital admissions across these numerous trials. Thus far, systematic five-year follow-up data have demonstrated no evidence of premature degeneration or failure of transcatheter heart valves. Currently there are ongoing trials to evaluate TAVR in the low risk population.

Mitral Valve Regurgitation

The mitral valve separates the left atrium from the left ventricle and helps control the flow of blood through these chambers as the heart pumps. Mitral regurgitation is another common valvular abnormality in adults in the United States, with 6% of people over 65 years of age, and almost 10% of people over 75 years of age being affected by significant mitral regurgitation. In mitral regurgitation, the mitral valve does not close properly when the left ventricle contracts and there is backwards flow of blood into the left atrium that can cause disabling symptoms of congestive heart failure, heart muscle dysfunction and an increased risk of death. When this leakage is severe, this can result in significant symptoms of congestive heart failure (shortness of breath, leg swelling, decreased exercise tolerance and energy), lightheadedness, palpitations, and decompensation of cardiac function (Figure 5). Untreated mitral regurgitation can result in enlargement and weakness of the heart muscle, causing decreased function and efficiency of the heart.

Figure 4c

All-Cause Mortality*

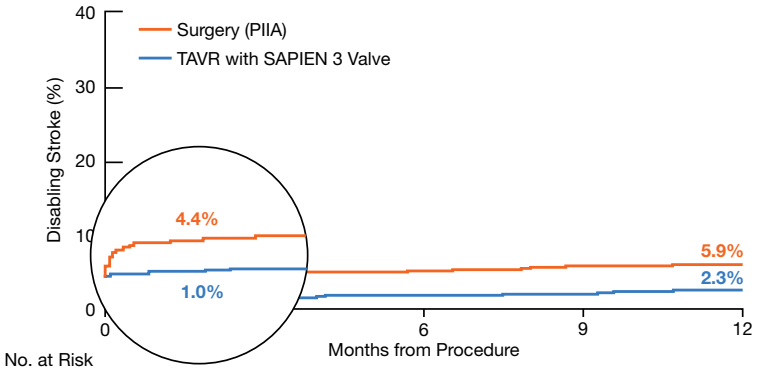


No. at Risk					
Surgery	944	859	836	808	795
SAPIEN 3 TAVR	1077	1043	1017	991	963

*The PARTNER II trial intermediate-risk cohort unadjusted clinical event rates.

Figure 4d

Disabling Stroke*

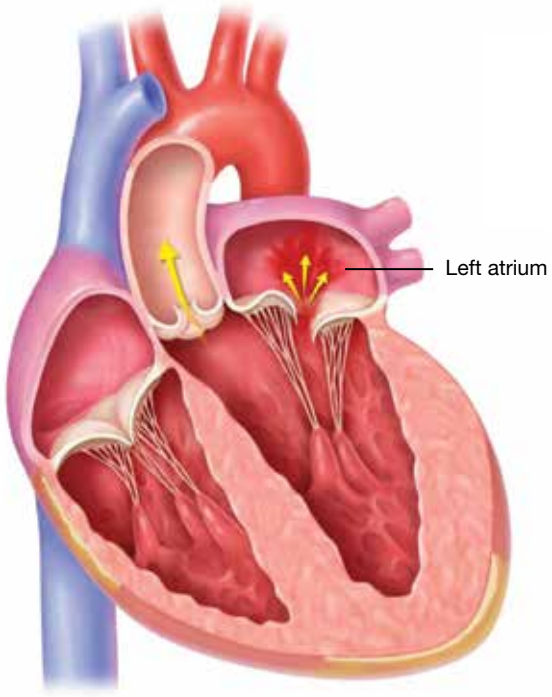


No. at Risk					
Surgery	944	825	806	778	764
SAPIEN 3 TAVR	1077	1033	1008	884	953

*The PARTNER II trial intermediate-risk cohort unadjusted clinical event rates.

Figure 5

In mitral regurgitation, the valve does not close properly. This causes blood to leak back (regurgitate) into the left atrium when the left ventricle contracts.



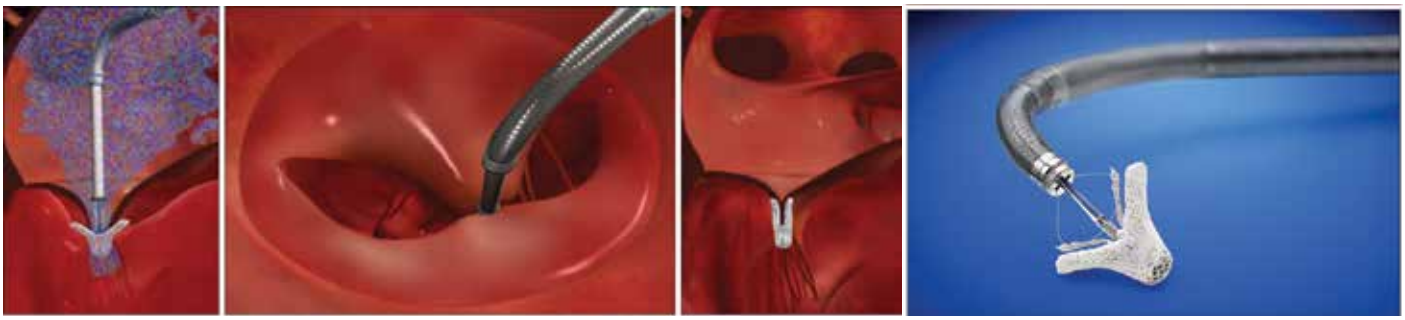
Traditional therapy for severe, symptomatic mitral regurgitation has been open heart surgery for mitral valve repair or replacement. Although this type of surgery is generally very effective for reducing mitral regurgitation severity, alleviating symptoms, and improving the function of the heart muscle, it is highly invasive. Because of the highly invasive nature of this surgery, many patients with severe symptomatic mitral regurgitation are often considered too high-risk for mitral valve surgery and therefore go untreated. Indeed, studies have shown that as few as 2% of patients with severe, symptomatic mitral regurgitation undergo surgery for this condition.

Transcatheter Mitral Valve Repair (TMVR)

Similar to aortic stenosis, there are a significant number of patients who have severe and clinically significant mitral regurgitation who are poor candidates for open-heart surgery for mitral valve repair or replacement and are treated with medical therapy. Ironically, as these patients become sicker with progressive heart muscle dysfunction, they become even poorer candidates for mitral valve surgery.

As is apparent, there was a great need for a non-surgical and minimally-invasive alternative to open-heart surgery for high-risk patients with significant mitral regurgitation. To meet this need, transcatheter mitral valve repair with the MitraClip system was developed. Transcatheter mitral valve repair with the MitraClip device allows for repair of the leaky mitral valve using one or more small clip-like devices placed on the valve percutaneously via femoral venous access (through the vein in the leg without surgery), similar in concept to a cardiac catheterization procedure. The MitraClip mitral valve repair procedure is performed on a beating heart and simulates an edge-to-edge

Figure 6



surgical repair of the leaky mitral valve without the need for any surgery (Figure 6).

The first successful MitraClip transcatheter mitral valve repair procedure was performed in 2003 in Caracas, Venezuela. Since then, more than 25,000 patients have successfully been treated worldwide. Data from the EVEREST I and EVEREST II studies of transcatheter mitral valve repair with the MitraClip system over the past decade led to the FDA approval of the MitraClip device in the U.S. on October 24, 2013 for high-risk patients with ≥ 3+ degenerative symptomatic mitral regurgitation. The safety of the MitraClip procedure and effectiveness in reducing the degree of mitral regurgitation was demonstrated in these studies. Additionally, studies demonstrated patients treated with MitraClip have improvement in congestive heart failure symptoms, improvement in quality of life, reduced rates of hospitalization for heart failure and improvement in heart muscle function. Because of the minimally-invasive nature of the MitraClip procedure, patients generally have a very quick recovery and typically have a hospital stay of less than three days.

Oklahoma Heart Institute's Approach to Valvular Heart Disease

Oklahoma Heart Institute has the most comprehensive structural heart and valve disease program in the state. Our program is collaborative, multidisciplinary and patient-centered.

The Valve Center at Oklahoma Heart Institute combines the expertise of physicians from non-invasive cardiology, cardiovascular imaging, interventional cardiology, cardiothoracic surgery and cardiac anesthesiology who work together to ensure our patients with valve disease receive the most appropriate, comprehensive, evidence-based and cutting-edge care (Figure 7).

All forms of valve disease repair and replacement are available at Oklahoma Heart Institute including a comprehensive valve surgery program, transcatheter aortic valve replacement (TAVR), transcatheter mitral valve repair (MitraClip), percutaneous balloon valvuloplasty/valvotomy for all valve disorders, as well as paravalvular leak closure procedures (closing leaks adjacent to previously placed valves).

We are proud to have performed over 250 TAVR procedures since May 2, 2012 and 50 MitraClip procedures since November of 2014.

Most patients undergoing TAVR at OHI will not require general anesthesia and typically will be discharged home within two days of the procedure. Similarly, most patients undergoing MitraClip are able to return home within two days of the procedure. They are subsequently followed closely in the Valve Center at OHI on an outpatient basis.

We look forward to providing the highest quality and most advanced care to our patients. For more information about the Valve Center at OHI, including informational and patient videos, please visit: www.oklahomaheart.com/TAVR.

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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CHICKEN AND BROWN RICE SOUP Serves 8

Easy and satisfying, soups are wonderful to have simmering on the stove during the busy holiday season. To make a vegetarian version, use low-sodium vegetable broth and substitute quartered button mushrooms or cubed firm tofu for the chicken.

8 cups low-sodium chicken broth, divided

1 medium onion, chopped

3 medium carrots, chopped

2 stalks celery, chopped

2 cups water

1 cup long-grain brown rice

1 small chicken breast, cut into 1/2-inch cubes

1 bay leaf

1 bunch kale or collard greens, thick stems removed and leaves thinly sliced

In a large pot over medium-high heat, bring 1/2 cup broth to a simmer. Add onion, carrots and celery and cook about 8 minutes or until onion is translucent, stirring occasionally. Add remaining 7 1/2 cups broth, water, rice, chicken and bay leaf. Bring to a boil. Reduce heat to a simmer, cover and cook about 35 minutes or until rice is tender and chicken is cooked through. Remove bay leaf and stir in kale. Continue cooking just until kale is wilted and tender, 3 to 5 minutes.

HERB CRUSTED GOAT CHEESE Serves 4 to 6

Use lots of fresh herbs to make this easy, elegant appetizer that's a perfect way to begin any festive gathering.

1 tablespoon finely chopped fresh thyme

1 tablespoon finely chopped fresh marjoram

1 tablespoon lemon zest

2 fresh sage leaves, finely chopped

2 fresh basil leaves, finely chopped

1 (4- to 6-ounce) log fresh goat cheese

Crostini or crackers for serving

In a pie plate, stir together thyme, marjoram, lemon zest, sage and basil. Roll cheese in mixed herbs until completely coated. Place cheese on a serving plate with crostini or crackers.

SWEET POTATO BACON BITES

Makes 2 dozen

Topped with crisp bacon, green onions and sour cream, these baked sweet potato hors d'oeuvres could be crowned the champion of your next cocktail party. For best results, look for sweet potatoes that are long and thin, roughly 2 1/2 inches wide.

8 slices bacon

2 large sweet potatoes (about 1 1/2 pounds), peeled and cut crosswise into (1/2-inch) thick rounds

1 tablespoon all-purpose flour

1 teaspoon fine sea salt, divided

Olive spray oil

1/2 cup sour cream or crème fraîche

Zest of 1 Satsuma tangerine, clementine or small orange

2 green onions, thinly sliced (about 1/4 cup)

Preheat the oven to 400°F. Bake bacon on a foil-lined baking sheet until almost crisp, about 15 minutes. Transfer to a paper towel-lined plate to let drain, and then finely chop.

In a large bowl, toss sweet potatoes with flour and 3/4 teaspoon salt. Spray a large baking sheet with oil and then arrange sweet potatoes in a single layer. Spray tops with oil and bake on the bottom third of the oven, flipping once, until golden brown and tender, 20 to 25 minutes; set aside to let cool until warm.

In a small bowl, stir together sour cream, remaining 1/4 teaspoon salt and zest. To serve, top each round of sweet potato with a dollop of sour cream, bacon and green onions.

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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?*

Carotid Artery Evaluation

1 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**

Cardiac Function Evaluation

2 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**

Abdominal Aorta Evaluation

3 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**

Ankle/Brachial Index

4 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**

Cardiac Calcium Score

5 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.

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