Heart Failure With Preserved Ejection Fraction
By Wayne N. Leimbach, Jr., MD

100 TAVRs at Oklahoma Heart Institute
By Kamran I. Muhammad, MD and Georgianne Tokarchik, APRN-CNS

Atrial Fibrillation Ablation: Where Are We Today?
By David Sandler, MD

Advances in the Percutaneous Treatment of Coronary Artery Chronic Total Occlusions
By Raj H. Chandwaney, MD

Sleep Apnea: A Serious but Treatable Health Epidemic
By Michael Newnam, MD
OUR EXPERIENCE IS YOUR EXPERIENCE

CARDIOVASCULAR SPECIALISTS  ADVANCED TECHNOLOGY  EXPERT PATIENT CARE

Oklahoma Heart Institute

TECHNOLOGY AND KNOW-HOW FOR RESULTS YOU CAN DEPEND ON

918.592.0999 | www.oklahomaheart.com | 1126 S. UTICA AVE. Oklahoma Heart Institute (The Heart Hospital) | 1265 S. UTICA (Utica Physicians Office)
9228 S. MINCO (South Print Physicians Office) | 8801 S. 101st E. Ave. (Hilgerwest South)
features

4 Heart Failure With Preserved Ejection Fraction
By Wayne N. Leimbach, Jr., MD, FACC, FSCAI, FCCP, FAHA, FACP

6 Whole Heart Healthy Recipes

8 100 TAVRs at Oklahoma Heart Institute
By Kamran I. Muhammad, MD, FACC, FSCAI and Georgianne Tokarchik, APRN-CNS

10 Atrial Fibrillation Ablation: Where Are We Today?
By David Sandler, MD, FACC, FHRS

16 Advances in the Percutaneous Treatment of Coronary Artery Chronic Total Occlusions
By Raj H. Chandwaney, MD, FACC, FSCAI, FSVM

20 Sleep Apnea: A Serious but Treatable Health Epidemic
By Michael Newnam, MD

This issue of Oklahoma Heart Institute Magazine encompasses several articles that update common clinical problems related to cardiovascular disease. Dr. David Sandler, Director of Electrophysiology, discusses how atrial fibrillation ablation therapies have become first line therapies for many patients with atrial fibrillation. He also provides a brief summary of the Oklahoma Heart Institute results for patients having both radiofrequency and cryoablation procedures. Dr. Kamran Muhammad, Director of the Valve and Structural Heart Disease Division, updates the transcatheter aortic valve replacement program at Oklahoma Heart Institute. The 100th patient to receive a stent valve was celebrated a couple of months ago. Dr. Raj Chandwaney, from the Division of Interventional Cardiology, highlights the increasing success rates treating chronic total occlusions in coronary arteries. Dr. Newnam, Co-Director of the Oklahoma Heart Institute Sleep Lab, highlights the importance of sleep disturbances and sleep apnea as they relate to many cardiovascular problems. Finally, the importance of heart failure with preserved left ventricular ejection fraction is discussed. This condition was formerly known as diastolic heart failure. Heart failure with preserved ejection fraction now accounts for half of patients with symptomatic heart failure.

I hope you find these articles informative and useful and appreciate any comments or suggestions.

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

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.
Heart Failure With Preserved Ejection Fraction

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

Heart failure is a clinical syndrome and is described as the inability of the heart to provide adequate cardiac output to the body at rest or with exertion, or to do so only in the setting of elevated cardiac filling pressures. Clinically, heart failure is characterized by breathlessness, fatigue, and edema caused by an abnormality of the heart.

Heart failure is a major epidemic challenging the health care system in the United States. There are approximately 5,700,000 heart failure patients in the United States. The annual incidence is greater than 500,000 cases, and it is the most frequent cause of hospitalization in patients over 65. Approximately 3 billion dollars (5.4% of total healthcare costs) is spent annually on this condition. There are 250,000 deaths annually due to heart failure. This contrasts with 550,000 cancer deaths and 15,008 deaths from AIDS.

What many healthcare providers fail to recognize is that approximately one-half of patients with symptoms of heart failure have preserved systolic function, known as heart failure with preserved ejection fraction (HFpEF).

Analysis of outcomes in populations with heart failure show that morbidity and mortality in HFpEF are similar to values observed in patients with heart failure and reduced ejection fraction (HFrEF).

Interest in heart failure with preserved ejection fraction began in the 1970s, as studies reported symptoms in patients with preserved left ventricular systolic function, but who had evidence of diastolic abnormalities from hypertrophic cardiomyopathies, left ventricular hypertrophy due to aortic stenosis, and due to prolonged hypertension. Because of these diastolic abnormalities, the term diastolic heart failure became commonly used to distinguish the heart failure syndrome associated with preserved ejection fraction from “systolic” heart failure, which corresponds to HFrEF. Because diastolic LV dysfunction is not unique to HFpEF, but also observed in patients with HFrEF, the term diastolic heart failure was changed to heart failure with preserved ejection fraction (HFpEF). In 1984, Daugherty, et al, described the condition of congestive heart failure with normal systolic function in the American Journal of Cardiology.

The pathophysiology of heart failure with preserved ejection fraction is a failure of the left ventricle to relax normally. Diastolic LV dysfunction results from increased myocardial stiffness. The two possible components to this increased stiffness are increased extracellular matrix and intrinsic cardiomyocyte stiffness. In the CHARM trial, similar signs and symptoms were found in patients with HFpEF and HFrEF. With the exception of an infrequent finding of an S3 in patients with heart failure with preserved ejection fraction, the symptoms of edema, orthopnea, PND, dyspnea, rales and cardiomegaly were similar between the two groups.

Predictors of heart failure with preserved ejection fraction included hypertension, atrial fibrillation, female sex and elevated NT-proBNP or BNP levels. This contrasted with the risk factors for heart failure with reduced ejection fraction, which included myocardial infarction and left bundle-branch block, as well as idiopathic and viral cardiomyopathies. The Framingham study found that the prognosis was equally poor for both. In the I-PRESERVE trial, the HFpEF patients had a mortality rate of 5.2% per year. Cardiovascular causes accounted for 60% of the deaths including sudden death, MI, and stroke. The most powerful predictors of adverse outcomes for patients with HFpEF were increased NT-proBNP, age, diabetes mellitus, and left ventricular ejection fraction.

The diagnosis HFpEF is frequently challenging and relies on clinical assessment and echo Doppler evaluations, and sometimes invasive hemodynamic
monitoring is necessary. The diagnosis of HFpEF requires the signs and symptoms of heart failure, normal LV systolic function with an ejection fraction greater than 50%, and evidence of left ventricular diastolic dysfunction including left ventricular hypertrophy, left atrial enlargement, increased BNP or NT-proBNP levels, and a left ventricular end diastolic pressure at cardiac catheterization of greater than 16 mmHg. BNP levels greater than 100 and NT-proBNP levels of greater than 220 mL are suggestive of heart failure with preserved ejection fraction in patients with signs and symptoms of heart failure.

In the outpatient clinic, it is sometimes cumbersome to make the diagnosis of HFpEF. This is in contrast to HFpEF where the diagnosis can be made by getting an echocardiogram or nuclear scan and finding a reduced ejection fraction. It is particularly difficult to diagnose HFpEF when patients present with a complaint of dyspnea on exertion, but do not have obvious evidence of fluid overload. The diagnostic algorithm in these patients is to get an echocardiogram to evaluate the ejection fraction. The echocardiogram will also look at left atrial dimensions. If the left atrial dimension is greater than 40 mL/m2, this is suggestive of elevated filling pressures. An elevated BNP or NT-proBNP of greater than 100 or 220 respectively, are also suggestive in patients with dyspnea on exertion. Invasive studies are sometimes required for the diagnosis of heart failure with preserved ejection fraction. An elevated left ventricular end diastolic pressure of greater than 16 is suggestive. An exercise pulmonary artery systolic pressure greater than or equal to 45 mmHg is diagnostic in the majority of patients with HFpEF. In a study by Borlaug in the Journal of Heart Failure in 2010, it was reported that an elevated exercise pulmonary artery systolic pressure of greater than 45 had a sensitivity of 96% and specificity of 95%.

Unlike HFpEF where medications have been found to significantly alter the natural history, effective therapies for the treatment of HFpEF have not yet been identified. Where beta-blockers, ACE inhibitors and angiotensin-receptor blockers, diuretics, and blockers of aldosterone have been shown to significantly improve the outcome of patients with HFpEF, diuretics have been used to treat the symptoms of HFpEF, but do not alter the natural history of the disease. It has been suggested that beta-blockers might improve the filling period for patients with HFpEF. This may be beneficial in patients with rapid heart rates, but may not be beneficial in patients with slower heart rates. In fact, chronotropic incompetence and an abnormal heart rate recovery are more common in patients with HFpEF. It is possible that some of the symptoms of dyspnea occur due to an inadequate ability to appropriately increase heart rate in patients with HFpEF.

Several studies have looked at the use of ACE inhibitors and angiotensin-receptor blockers, as well as beta-blockers for the treatment of HFpEF. These studies did not find major differences in mortality or need for hospitalization. A recently published trial, TOPCAT, had as its objective to determine if treatment with spironolactone can produce a clinically meaningful reduction in the composite endpoint of cardiovascular mortality, aborted cardiac arrest or hospitalization for the management of heart failure compared with placebo in adults with heart failure with preserved ejection fraction. The primary endpoint of the study was reported to be negative, with no significant difference compared to placebo. Exploratory post-hoc analysis, however, demonstrated that if the results from Russia and the Republic of Georgia were excluded, and the rest of the data from other studies in the United States, Canada, Argentina and Brazil were analyzed, the results did show a 31.8% reduction in events with the use of spironolactone. The results were statistically significant, but due to the fact that it was a post-hoc analysis, these results would be suggestive, but not conclusive, that inhibition of aldosterone by spironolactone is beneficial.

Research is ongoing regarding the multiple potential mechanisms for therapeutic interventions. Studies are evaluating rate adaptive atrial pacing to optimize cardiac performance in patients with HFpEF. A channel blocker, ivabradine, is being studied in animal models. Studies are looking at the use of ALT-711, which breaks glucose crosslinks and improves ventricular compliance. A macro molecule involved in LV stiffness, titin, is also being researched. In addition, a study has been initiated looking at the use of an angiotensin receptor blocker combined with nephrilysin inhibitor for the treatment of HFpEF.

Previously, inhibitors of neutral endopeptidase along with the renin angiotensin system inhibitors showed significant reductions in blood pressures. There was also suggestion of benefit in heart failure; however, the use of these agents (Omapatrilat) resulted in increased risk of angioedema. The PARAGON-HF trial is ongoing and looks at the use of a neutral endopeptidase inhibitor along with valsartan to inhibit the renin angiotensin system.

This trial has just started, and it will be several years before the results are known.

In summary, heart failure with preserved ejection fraction is a common problem. Since there are no definite therapeutic strategies to improve the prognosis, it has become a major challenge in regards to treatment.

Because heart failure with preserved ejection fraction is a common problem and there are no definite therapeutic strategies to improve the prognosis, it has become a major challenge in regards to treatment.

Wayne N. Leimbach, Jr., is a specialist in interventional cardiology with expertise in cardiac catheterization, coronary intervention (including angioplasty, stent placement, atherectomy, intravascular ultrasound), peripheral vascular interventions, including carotid stenting, as well as interventional therapies for structural heart disease, including percutaneous closure of PFOs, ASDs and PDAs, and percutaneous placement of stent valves (TAVR).
**Carrot-Raisin Baked Oatmeal**  
_Serves 8_  
Take oatmeal on the go with this delicious baked version, somewhat of a guilt-free carrot cake chock full of oats. Make in a pie plate for wedges or in a mini-muffin pan for bite-size servings.

- Canola spray oil
- 2 cups rolled oats
- 1/2 cup chopped pecans, toasted
- 1/2 cup raisins
- 1 teaspoon baking powder
- 3/4 teaspoon ground cinnamon
- 1/2 teaspoon fine sea salt
- 1 cup lowfat (1%) milk or nondairy beverage
- 2 eggs
- 2 teaspoons pure vanilla extract
- 1 cup shredded carrots

Preheat the oven to 350°F. Lightly coat a 9- to 9 1/2-inch pie plate or a 24-cup mini-muffin pan with spray oil.

In a large bowl, stir together oats, pecans, raisins, baking powder, cinnamon and salt. In a separate bowl, whisk together milk, eggs and vanilla until evenly blended. Stir in carrots. Add carrot mixture to oat mixture and stir until evenly blended.

Transfer batter to the prepared pie plate or spoon into the muffin cups. Bake until firm and golden brown on top, 45 minutes for the pie plate or 30 minutes for the muffin pan. Let cool slightly. If baking in a pie plate, cut into 8 wedges to serve.

**Apple, Sage and Turkey Meatloaf**  
_Serves 8_  
This moist and delicious meatloaf lets the deep, rich flavor of turkey shine through. Shredded apple adds moisture and a light sweetness to the mix, and sage makes it irresistibly fragrant.

- 2 apples, cored, peeled and grated
- 1 large yellow onion, finely chopped (about 1 cup)
- 2/3 cup Italian-style (seasoned) bread crumbs
- 1/2 cup low-fat (1%) milk
- 2 pounds ground turkey, preferably a mix of white and dark meat
- 1/4 cup chopped fresh sage leaves
- 1 large egg, lightly beaten
- 1 teaspoon fine sea salt
- 1/2 teaspoon freshly ground black pepper
- 1/4 cup tomato sauce (optional), plus more for serving

Preheat the oven to 400°F. Line a small baking sheet with parchment paper.

Combine apples, onion, bread crumbs and milk in a large bowl and let stand 5 minutes to soften bread crumbs. Add turkey, sage, egg, salt and pepper and mix until combined. Scrape the mixture onto the baking sheet. With water-moistened hands, shape the mixture into a loaf about 10 inches long and 5 inches wide. Spread top of loaf with 1/4 cup of the tomato sauce, if using, and bake until meatloaf is lightly browned and cooked through (an instant-read thermometer inserted into the center should register 165°F), 50 to 60 minutes.

Let meatloaf sit 10 minutes before slicing and serving. Serve with warmed tomato sauce if desired.
According to the American Heart Association, many people experience no symptoms before having a heart attack or stroke.

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

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

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

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

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

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

---

**Screening Tests that Can Save Your Life and Prevent Heart Attack and Stroke**

- Fast, accurate and painless
- No physician referral required
- Open to the general public
- Schedule screenings 1-4 and receive a $20 discount

Call today for your appointment!

918.592.0999

Exclusively at Oklahoma Heart Institute, a trusted name in Northeast Oklahoma for more than 20 years.

Oklahoma Heart Institute
A Nationally Recognized Cardiovascular Institute

918.592.0999 • OklahomaHeart.com

- Heart Hospital, 1120 S. Utica Ave.
- Hillcrest Hospital South, 8801 S. 101st East Ave.
- Utica Physicians Office, 1265 S. Utica Ave.
- SouthPointe Physicians Office, 9228 S. Mingo Rd.
100 TAVRs at Oklahoma Heart Institute

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

On July 22, 2014, Oklahoma Heart Institute’s valve team performed the 100th transcatheter aortic valve replacement (TAVR) procedure at our facility. This represents a highly significant milestone for our patients, institution and community. In the next few pages I will share with you the life-saving role of TAVR, the history of our TAVR program, the important milestones and “firsts” that we have achieved, and our excellent outcomes over the past three years.

Aortic Stenosis and Transcatheter Aortic Valve Replacement

Aortic stenosis is the most common cardiac valvular abnormality in the United States. This disorder results in restricted opening of the main valve of the heart that separates the left ventricle from the aorta. It is estimated that aortic stenosis affects approximately 5 of every 10,000 adults, with the prevalence increasing with age. Severe aortic stenosis results in severe symptoms of congestive heart failure (shortness of breath, leg swelling, pulmonary edema), chest pain/angina or syncope (nearly passing out or passing out). 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%. 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 for severe aortic stenosis, is generally associated with low operative mortality, and is 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 patients with severe aortic stenosis, there remain a large number of patients with severe aortic stenosis that go untreated. Indeed, numerous studies over the past decade have shown that at least 40% of patients with severe aortic stenosis never undergo surgical aortic valve replacement.

Transcatheter aortic valve replacement (TAVR) has been developed as a minimally-invasive approach to aortic valve replacement in patients with severe symptomatic aortic stenosis who are high-risk for surgical aortic valve replacement. Major trials of TAVR across the US and the world have demonstrated that it is an extremely effective therapy in this population, dramatically improving quality of life, reducing hospital admissions and markedly improving survival. In fact, recent data have demonstrated that TAVR is superior to surgical aortic valve replacement in reducing mortality in high-risk patients.

In contrast to surgical aortic valve replacement, TAVR is performed without major surgical incisions, and generally there is no need to stop the heart or use cardiopulmonary bypass (heart-lung machine) with TAVR as compared with surgery. Most TAVR procedures can be performed percutaneously (without any surgery) through the femoral artery (major artery in the groin), similar in concept to a heart catheterization procedure. Because of this, most patients undergoing transfemoral TAVR are able to go home within 2-4 days of...
We have achieved many firsts in a short time period, including performing the first alternative-access TAVRs in the city, the first valve-in-valve TAVR in the state as well as the first TAVR without general anesthesia in the state (Table 1). Now we are the first program in the city to have achieved the milestone of 100 TAVR procedures.

Table 1

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2, 2012</td>
<td>First TAVR in Tulsa</td>
</tr>
<tr>
<td>Nov. 13, 2012</td>
<td>First transapical TAVR in Tulsa</td>
</tr>
<tr>
<td>June 4, 2013</td>
<td>First transaortic TAVR in Tulsa</td>
</tr>
<tr>
<td>Nov. 26, 2013</td>
<td>First valve-in-valve TAVR in Tulsa</td>
</tr>
<tr>
<td>Feb. 21, 2014</td>
<td>First commercial CoreValve TAVR in Oklahoma</td>
</tr>
<tr>
<td>Feb. 21, 2014</td>
<td>First TAVR without general anesthesia in Oklahoma</td>
</tr>
<tr>
<td>June 24, 2014</td>
<td>First commercial Sapien XT TAVR in Oklahoma</td>
</tr>
</tbody>
</table>

We have achieved many firsts in a short time period, including performing the first alternative-access TAVRs in the city, the first valve-in-valve TAVR in the state as well as the first TAVR without general anesthesia in the state (Table 1). Now we are the first program in Tulsa to have achieved the milestone of 100 TAVR procedures.

Achieving the milestone of 100 TAVR procedures at Oklahoma Heart Institute is something we are very proud of. It is well known that larger procedural volumes are associated with better outcomes in medicine and surgery, and this is certainly true for TAVR. Our TAVR volumes are more than double that of any program in Tulsa, and are in the top 15% of TAVR programs nationally. Out of approximately 300 centers in the US that perform TAVR, only about 50 have performed more than 100 TAVR procedures. This puts Oklahoma Heart Institute into an elite and exclusive group of advanced heart and valve centers in the United States.

With this spirit of innovation and advancement, Oklahoma Heart Institute has always put patients first. This is evident in the excellent outcomes we have experienced following TAVR. Table 2 summarizes the age range and demographics of the patients treated at Oklahoma Heart Institute with TAVR. As is noted, the average age of patients undergoing TAVR at Oklahoma Heart Institute is 82 years. Additionally, our patients typically have multiple serious co-morbidities, and more than a quarter (29%) have had previous open-heart surgery. Table 3 highlights important outcomes from our TAVR program, including 30-day and 1-year mortality rates as well as stroke, with comparisons to nationally reported data. As noted, our outcomes are superior to nationally reported data, consistent with our mission to be the premier valve program in the region. Additionally, as also noted in Table 3, the average patient length of stay after TAVR at our institution is very low (3.4 days for transfemoral cases), and significantly lower than nationally reported data.

Conclusions

With your support, Oklahoma Heart Institute will continue to expand its valve and TAVR programs over the coming months and years. It is expected that the technology associated with TAVR will continue to improve, thereby making the procedure safer and available to larger numbers of patients. Additionally, we expect that TAVR will be approved for lower risk populations in the future. Percutaneous, minimally-invasive technology for mitral valve repair has also been recently approved but is currently only available at a few centers in the US. Oklahoma Heart Institute aims to be the first program to bring this technology to Tulsa and the region in the next few months, similar to what was achieved with TAVR. With these and other initiatives, we are confident that Oklahoma Heart Institute will remain the premier and most comprehensive valve and TAVR center in the region.

Kamran I. Muhammad, MD is a subspecialist in interventional cardiology at Oklahoma Heart Institute in Tulsa, OK with expertise in cardiac catheterization, coronary intervention (including angioplasty, stent placement, atherectomy, intravascular imaging), peripheral vascular intervention (including carotid intervention), as well as interventional therapies for structural heart disease, including PFO, ASD, and valvular disease. Dr. Muhammad serves as the Director of the Structural Heart Disease and TAVR programs at Oklahoma Heart Institute.
Atrial Fibrillation Ablation: Where Are We Today?

By David Sandler, MD, FACC, FHRS

Atrial fibrillation (AF) remains the most commonly encountered heart rhythm abnormality in the United States. The disease increases with age and is often associated with other forms of heart disease. AF doubles the risk of stroke and dementia while tripling the risk of congestive heart failure. Furthermore, AF accounts for approximately 500,000 hospital admissions in the US annually.

The goals of AF therapy are two-fold: stroke prevention and symptom improvement. This article is devoted to symptom prevention with catheter ablation.

**Mechanism**

When trying to understand the mechanism of AF, it is important to recognize the 4 types of AF (Table 1). Patients with paroxysmal AF have self-limiting episodes which usually last hours to a few days. These patients usually have focal triggers but minimal scarring in their atria. Patients with persistent AF need to be shocked back into normal rhythm, or the episode could continue indefinitely. Often, these patients have scarring and dilatation of the atrium. Patients with long-standing persistent AF have been in AF consistently for over one year, but have decided that they would like an attempt at restoring normal rhythm. Permanent AF applies to those patients in whom a decision has been made (regardless of AF duration) that no further attempts will be made at returning the heart to normal rhythm.

**Initial Experience with Catheter Ablation for AF**

Over the past 20 years, catheter ablation has become the mainstay of preventing AF episodes in symptomatic patients. With improved efficacy and safety, the ablation procedure has emerged from a last resort to a first line therapy for appropriate candidates.

In the 1990s, pioneering work identified that over 90% of AF episodes are triggered from within the pulmonary veins in patients with paroxysmal AF. These are the veins that return the blood from the lungs back to the heart. Initial catheter ablations for AF were lengthy and often ineffective, as the operator would wait for firing from an individual vein and then target the actual trigger. The procedure has evolved dramatically over two decades. In today's procedure, each pulmonary vein is electrically isolated. This has improved success and
reduced procedure times dramatically.

In order to sever the electrical connections to the pulmonary veins, energy is applied to burn the tissue or cryo solutions are used to freeze the tissue. When using the heating method, a catheter emits radiofrequency energy at the junction between the pulmonary vein and the left atrium of the heart. This process is repeated in a circular fashion around the circumference of the veins until the vein is electrically isolated (Figure 1). In order to confirm that no gaps of untreated tissue are left behind, a three-dimensional map is created. Just in the last year, advances in catheter technology have improved the procedure by adding a force-sensing tip to the catheter, allowing better adhesion to ensure optimal tissue contact. Two separate trials have shown this to improve success over traditional catheters, (Neuzil P et al Circ Arrhythm Electrophysiol, 2013;6:327-333 and Natale A et al J Am Coll Cardiol 2014;64:647–56). When freezing the tissue, a balloon with liquid nitrogen is inflated in the atrium and pressed against the pulmonary vein entrance. This creates a uniform, circumferential lesion around each vein resulting in electrical isolation (Figure 2). This method has been shown to carry similar efficacy as radiofrequency (Jourda F et al Europace, 2014 Epub and Packer DL et al J Am Coll Cardiol, 2013;61:1713–23).

Progression of Atrial Fibrillation
AF is a progressive disease in most patients, with frequency and duration of episodes worsening with time. As you might expect, the success at maintaining normal rhythm is inversely related to their time in AF. Early treatment is paramount to preventing AF successfully. For patients with paroxysmal AF, eliminating triggers alone often prevents recurrence. In patients with persistent AF, often the substrate must be modified as well. This is based on the amount of scarring that has developed in the atria. A recent trial showed that the amount of scarring can be detected by MRI and can predict the success of catheter ablation (Figure 5). (DECAAF Trial: Marrouche, NF et al JAMA. 2014;311(5):498-506).

OHI Experience
OHI began performing AF ablation in 2003. We are currently on pace to perform our 1000th AF ablation before the end of the year. We continue to prevent recurrent AF in over 80% of patients with paroxysmal AF and 60% with persistent AF. Most patients with paroxysmal AF are taken off rhythm drugs, and those at low stroke risk are taken off blood thinners. Less than 20% of patients require a second procedure.

Conclusion
AF is a common disease and is associated with stroke, dementia and congestive heart failure. Ablation technologies have allowed for improved success and lower complications over the course of two decades. OHI is proud to be recognized as a regional leader in AF management and continues to bring state-of-the-art technologies to our region.

David A. Sandler, MD is a cardiologist with subspecialty expertise in electrophysiology, complex ablation, and atrial fibrillation management.
Interventional Cardiology
- Cardiac Catheterization
- Coronary Angioplasty
- Multivessel Angioplasty and Stenting
- Atherectomy
- Rotablator Atherectomy
- Thrombolytic Therapy
- Coronary Stents
- Carotid Stenting
- Fractional Flow Reserve
- Intravascular Ultrasound
- Myocardial Biopsy
- Percutaneous ASD Closures
- Percutaneous PFO Closures
- Impella Circulatory Support
- Catheter Hypothermia for Cardiac Arrest Patients
- Transcatheter Aortic Valve Replacement (TAVR)
- Venous Ablation

Noninvasive Cardiology
- CT Angiography
- CT Heart Scan
- Cardiac and Vascular Screening Services
- Nuclear Cardiology
- Echo and Doppler Studies
- Nuclear and Echocardiographic Exercise and Pharmacological Stress Testing
- Retinal Imaging
- Thyroid Ultrasound
- Transesophageal Echocardiography, Arterial Venous Peripheral Vascular Imaging and Doppler Studies
- Peripheral Arterial Doppler and Duplex Imaging
- Cardiovascular Magnetic Resonance Imaging
- External Counterpulsation (ECP) Therapy
- Transcranial Doppler
- Aquapheresis Therapy

Electrophysiology
- Electrophysiology Studies
- Ablation Therapy
- Pacemaker Implantation
- Pacemaker and Lead Extraction
- Pacemaker Programming
- Pacemaker Monitoring and Clinic
- Implantable Cardioverter Defibrillator (ICD) Replacement
- ICD and Hardware Removal
- ICD Programming
- ICD Monitoring and Clinic
- Holter Monitoring and Interpretation
- 30 Day Cardiac Event Monitors
- Implantation and Interpretation of Long-Term Heart Monitors
- Signal Averaged EKGs and Interpretation
- Head Up Tilt Testing and Interpretation
- Direct Current Cardioversion
- Antiarrhythmic Drug Loading and Monitoring

Metabolic Disorders
- Diabetes
- Thyroid
- Hypertension
- Other Endocrine Problems

Specialty Clinics
- Advanced Center for Atrial Fibrillation
- Arrhythmia 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 Carts
- 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 Thoracoscopic 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

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
Wayne N. Leimbach, Jr., MD, FACC, FACP, FSCAI, FCPP, FAHA
Dr. Leimbach is a specialist in interventional cardiology with expertise in cardiac catheterization, coronary intervention (including angioplasty, stent placement, atherectomy, intravascular ultrasound), peripheral vascular interventions, as well as interventional therapies for structural heart disease, such as percutaneous closure of PFOs, ASDs and PAs, and percutaneous placement of stent valves (TAVR). He is Director of the Cardiac and Interventional Laboratories at Oklahoma Heart Institute Hospital and also is 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 received is Bachelor of Science degree in physics at Xavier University in Cincinnati 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, RVPI
Dr. Sonnenschein specializes in echocardiography and noninvasive peripheral vascular imaging. He is past Director of Peripheral Vascular Imaging and Noninvasive Laboratory 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 Cardiac Imaging and 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, 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 cardic 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 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 Chief of Cardiology at Oklahoma Heart Institute, where he is Director of the Congestive Heart Failure, C.A.R.E. Center and the Adolescent and Adult Congenital Heart Clinic. He is 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 the Mayo Clinic in Rochester, Minnesota. Dr. Kaneshige 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 Cardiology at Creighton University School of Medicine, where he was Director of the Noninvasive Cardiology Imaging and Hemodynamic Laboratory.
Board certified in Internal Medicine, Cardiovascular Disease, and Adult Transesophageal Echocardiography

Edward T. Martin, MS, MD, FACC, FACP, FAHA
Dr. Martin is a noninvasive cardiologist with specialty expertise in non-invasive imaging. He is Director of Cardiovascular Magnetic Resonance Imaging at Oklahoma Heart Institute and the College of Medicine – Tulsa. 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. Dr. Martin’s Internal Medicine Internship and Residency training were performed 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 an editorial board member of the Journal of Cardiovascular Magnetic Resonance.
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 at Oklahoma Heart Institute Hospital and also is Chief of Cardiology, 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, FACC
Dr. Hanson is a specialist in Endocrinology and Metabolic Medicine. He is Clinical Associate Professor of Medicine at the 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 Internship 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 advanced patient management. He 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 in 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, FSVT
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 interventions. Dr. Chandwaney is 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.
Kelly R. Flesner, MD

Dr. Flesner is a subspecialist in Endocrinology, Metabolism and Hypertension at the University of Oklahoma. She completed her residency at the University of Oklahoma and her fellowship in Endocrinology and Nuclear Medicine at the Mayo Clinic. Dr. Flesner specializes in diabetes and endocrine disorders, including thyroid disease, adrenal disease, and pituitary tumors.

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

Dr. Smith is a subspecialist in Interventional Cardiology and Vascular Medicine. He completed his fellowship in Interventional Cardiology at the University of Kansas Medical Center and his fellowship in Vascular Medicine at the Mayo Clinic. Dr. Smith is a specialist in percutaneous coronary intervention, peripheral vascular disease, and interventional cardiology.

John S. Tulloch, MD

Dr. Tulloch is a noninvasive cardiologist with expertise in nuclear cardiology, echocardiography, and peripheral vascular disease. He completed his fellowship in Cardiac Electrophysiology and Nuclear Cardiology at the University of Virginia and his fellowship in Cardiovascular Medicine at the Mayo Clinic. Dr. Tulloch is a subspecialist in rhythm disorders and structural heart disease, including atrial fibrillation, heart failure, and valvular disease.

Cristin M. Bruns, MD

Dr. Bruns is a specialist in Endocrinology, Diabetes, and Metabolism. She completed her fellowship in Endocrinology, Diabetes, and Metabolism at the Mayo Clinic. Dr. Bruns is a specialist in diabetes and endocrine disorders, including thyroid disease, adrenal disease, and pituitary tumors.

Douglas A. Davies, MD, FACC

Dr. Davies is a hospital-based cardiologist who provides continuity of care for patients admitted to Oklahoma Heart Institute – Hospital. He completed his fellowship in Cardiac Electrophysiology and Nuclear Cardiology at the University of Colorado. Dr. Davies is a specialist in rhythm disorders and structural heart disease, including atrial fibrillation, heart failure, and valvular disease.

Kamran I. Muhammad, MD, FACC, FSCAI

Dr. Muhammad is a subspecialist in Interventional Cardiology. He completed his fellowship in Interventional Cardiology at the Cleveland Clinic and his fellowship in Cardiac Catheterization and Coronary Angiography at the University of Pennsylvania. Dr. Muhammad is a specialist in percutaneous coronary intervention and percutaneous valvular intervention.
Dr. K. Naaman, DO, FACC
Dr. K. Naaman 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. He is a specialist in acute myocardial infarction. Dr. Naaman completed his Interventional and Clinical Cardiology Fellowships at Oklahoma State University Medical Center and his Internal Medicine Residency and Fellowship at the Penn State Milton S. Hershey Medical Center in Hershey, PA. Dr. Naaman 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

Dr. Stephen C. Dobratz, MD, FACC
Dr. Dobratz specializes in diagnostic and interventional cardiology, including cardiac catheterization, peripheral angiography, pacemakers and defibrillators, carotid stenting, carotid nuclear studies, cardiac computed tomography, transesophageal echo and echocardiograms. He completed his Fellowship in Cardiology at Allegheny General Hospital in Pittsburgh, Pennsylvania. Dr. Dobratz completed his Interventional Cardiology Fellowship 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

Dr. Jana R. Loveless, MD
Dr. Loveless is a sleep specialist, with expertise in the diagnosis and treatment of sleep disorders. Prior to joining Oklahoma Heart Institute, Dr. Loveless was with Nocturnal of Tulsa, Warner Clinic, and Cypress 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

Dr. Mathew B. Good, DO
Dr. Good is an invasive/noninvasive cardiologist specialist with expertise in adult echocardiography, nuclear cardiology, cardiac computed tomography, peripheral vascular ultrasound and cardiology. 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 Science in Tulsa and his Bachelor of Arts degree from the University of Colorado in Boulder.
Board certified in Internal Medicine and Cardiovascular Computed Tomography

Dr. Sandra E. Rodriguez, MD
Dr. Rodriguez is a noninvasive cardiologist specialist with expertise in congestive heart failure and transplants. She completed an Advanced Heart Failure/Transplant Fellowship at the University of Colorado Hospital in Aurora, Colorado and her Cardiology Diseases Fellowship at Texas Tech University Health Sciences Center in Lubbock Texas. Dr. Rodriguez completed her Internal Medicine Residency at Texas Tech and the Universidad El Bosque in Bogota, Colombia. She earned her medical degree from Medicine School, Escuela de Medicina “Juan N. Corpas,” in Bogota.
Board certified in Internal Medicine, Cardiovascular Disease and Advanced Heart Failure/Transplant Cardiology

Dr. 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, vascular ultrasound and peripheral vascular interventional procedures.

Dr. 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 Internal Medicine, Cardiovascular Disease and Electrophysiology

Dr. 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 Northwestern University in Northfield, Vermont.
Board certified in General Surgery and Thoracic Surgery

Dr. Michael B. Newnam, MD
Dr. Newnam 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
Cardiovascular disease remains the number one killer in the United States. One of every three deaths is due to cardiovascular disease. The majority (approximately 50%) of cardiovascular disease deaths are attributable to coronary heart disease. About every 25 seconds, an American will have a coronary event, and every minute someone will die from one. Locally, the statistics are more concerning. The coronary heart disease death rate in the state of Oklahoma ranks as the 49th worst in the country.\(^1\)

Percutaneous coronary intervention is an important technique to support the care for patients with coronary heart disease. Dr. Andreas Gruentzig performed the first human coronary angioplasty procedure in 1977.\(^2\) Since then, percutaneous coronary intervention techniques have evolved impressively. A major advance in the field was the introduction of coronary stents in the early 1990s. By reducing the risk for acute closure related to elastic recoil and/or coronary dissection, coronary stents rendered percutaneous coronary intervention a safer procedure. Cardiovascular surgeons were no longer required to be present on “standby” during percutaneous coronary interventions. Additionally, randomized trials validated that coronary stents facilitate optimized acute gain and hence reduce long term restenosis rates.\(^3\) These observations subsequently led to exponential growth in the number of percutaneous coronary interventions performed in the United States. Eventually, novel alloys were used instead of stainless steel to allow the construction of coronary stents with thinner struts. These thinner strut stents are more flexible and allow delivery through tortuous vessels previously considered untreatable with the original rigid stainless steel coronary stents. Advanced techniques, such as rotational atherectomy, were introduced to facilitate percutaneous coronary interventions in patients with more challenging coronary anatomy such as densely fibrotic or calcified vessels also once considered untreatable with standard angioplasty or coronary stenting techniques. Ultimately, drug eluting stents were introduced to further reduce late restenosis rates and enhance the long term durability of percutaneous coronary intervention.\(^4\) Studies examining the current use of second generation drug eluting stents suggest additional improvements in the long term benefits achieved that may ultimately rival the durability achieved with coronary artery bypass surgery.\(^5\)\(^6\)

Via the numerous technical advancements listed above, percutaneous coronary intervention plays a major role in the care of patients with coronary heart disease. For patients with acute coronary syndromes (unstable angina or acute myocardial infarction), studies demonstrate percutaneous coronary intervention clearly reduces major adverse cardiovascular events such as recurrent myocardial infarction, and/or death.\(^7\) For patients with chronic coronary heart disease, percutaneous coronary intervention provides symptomatic relief to patients with stable angina. Thus far, randomized studies have failed to demonstrate reductions in mortality in patients with stable angina treated with percutaneous coronary intervention. Large contemporary randomized studies designed to examine this issue may be limited by possible selection bias suggested by the large ratio of patients screened and consented to those who are actually randomized (i.e. 15.5 patients were screened for the COURAGE trial for every one patient that was actually randomized in the study).\(^8\) For example, patients who were screened for such studies were often not randomized after the diagnostic coronary angiogram was performed because the interventional cardiologists intuitively believed that the patient’s coronary anatomy was too high risk to allow possible randomization to medical therapy which may place the patient’s life in danger. As a result of this selection bias, contemporary randomized trials that were designed to test whether or not percutaneous coronary intervention is superior to medical therapy in patients with stable angina, may have only proved that if an experienced, thoughtful, and concerned interventional cardiologist believes an individual patient’s coronary anatomy can be treated with either percutaneous coronary intervention or medical therapy, they are usually correct.

Chronic total occlusion (CTO) is a term used to describe a coronary artery that is completely blocked for at least 3 months. CTOs are very prevalent as they are documented in up to 20% of diagnostic angiograms.\(^9\) Major coronary arteries with CTOs are sometimes supported via complex networks of collateral blood vessels from the remaining patent coronary arteries. Although arteries with a collateralized CTO are often receiving enough arterial blood flow via the collateral network to prevent complete infarction in the territory fed by the artery with the CTO, patients often experience exertional angina because the myocardium is still ischemic due to suboptimal arterial blood flow.

Percutaneous coronary interventions of CTOs are very challenging. The initial step required during percutaneous coronary intervention involves advancing an intracoronary guidewire across the blockage. The guidewire provides a platform over which balloons, stents, and any other ancillary equipment can be safely advanced into the coronary artery to treat the blockage. During CTO percutaneous coronary intervention, this initial step is usually difficult and sometimes impossible to achieve. The CTO is often densely fibrotic and impassable. Additionally, it is sometimes difficult for the interventional cardiologist to understand which direction the guidewire should be directed because the distal coronary artery is not adequately visualized (due to the more proximal CTO preventing flow to the distal segments of the artery). Because of these challenges, percutaneous coronary interventions in CTOs are often regarded as the “final frontier” in the field of percutaneous coronary intervention.

The challenges associated with coronary CTO percutaneous coronary intervention have resulted in a more conservative strategy regarding their management. In patients with multivessel coronary artery disease who are found to have a coronary CTO, the presence of the CTO is often the primary factor that leads to referral for coronary artery bypass surgery. In patients with single vessel coronary artery disease found to have a cor-
onary CTO, percutaneous coronary intervention attempts have typically been reserved for those patients who demonstrate severe angina despite optimized medical therapy. Recently published research suggests that the current paradigm used to manage patients with coronary CTO may need modification.

Research published earlier this year in the Journal of the American College of Cardiology analyzed the outcomes of all patients who underwent an attempted coronary CTO percutaneous coronary intervention in the United Kingdom between January 1, 2005 and December 31, 2009. Data from the United Kingdom Central Cardiac Audit Database revealed a total of 13,443 patients who underwent 14,439 coronary CTO procedures. This large analysis revealed that the coronary CTO percutaneous coronary intervention was successful in 10,199 procedures (70.6% success rate). Remarkably, a successful coronary CTO procedure was discovered to be associated with improved long-term survival (Figure 1). This finding challenges the current dogma that suggests only patients with severe angina refractory to medical therapy should undergo an attempt at coronary CTO percutaneous coronary intervention.

In addition to this groundbreaking discovery, several other important findings were observed in this study. First, patients with complete revascularization were found to have improved survival compared to those with partial revascularization; patients with partial revascularization were found to have improved survival compared to those with failed revascularization (Figure 2). This observation reinforces the intuitive belief that offering patients with multivessel coronary artery disease complete revascularization whenever possible is critically important. Second, the analysis suggests that although opening a major coronary artery CTO was associated with reduced mortality, the survival benefit was not related to the identity of the coronary artery (Figure 3). In other words, a significant survival benefit was observed regardless of whether the coronary CTO procedure was successful in the left anterior descending, circumflex, or right coronary arteries.

Fortunately, there have been advancements in the percutaneous techniques available to treat coronary CTOs. The most important advancement in the field of CTO percutaneous coronary intervention is the use of the dual guide catheter technique that allows operators to better visualize the distal target vessel and assess the true length of the CTO. With the dual guide catheter technique, operators access both femoral arteries so that guide catheters can be placed in both left and right coronary arteries. Operators then attempt to advance a coronary guidewire through the CTO in an antegrade manner through the guide catheter that is engaged in the culprit artery with simultaneous contrast injections through the contralateral guide catheter to visualize the distal target vessel via the collateral network.
This technique aids interventionalists by providing visualization of the distal target vessel so operators can clearly understand the direction to aim the guidewire as it is advanced through the CTO. Also, once the wire is advanced past the length of the CTO, operators can inject contrast dye through the contralateral guide catheter to confirm that the guidewire is in the true lumen of the vessel rather than in a dissection plane or in an extravascular space. Before performing balloon angioplasty it is critical to confirm placement of the guidewire in the true lumen of the distal vessel to avoid creation of a large perforation.

Additionally, use of the dual guide catheter technique may allow retrograde crossing of the CTO if antegrade attempts fail. Retrograde crossing involves advancement of a guidewire and support catheter through the contralateral guide catheter, through a collateral vessel, into the distal target vessel and finally through the CTO in a retrograde manner (Figure 4). In some cases, the distal cap of the CTO may be softer than the proximal cap allowing easier retrograde passage of the guidewire rather than antegrade passage. In other cases, proximal anatomic ambiguity (branch vessels adjacent to the proximal CTO cap cause uncertainty regarding the exact location of the proximal CTO cap) may be overcome using retrograde techniques.

In addition to the dual guide catheter technique described above, advancements have been made in the tools interventional cardiologists now have available for use during CTO percutaneous coronary interventions. The most important of these new tools available are the specially designed wires now available for use during CTO percutaneous interventions. CTO wires are available in gradually increasing degrees of stiffness to facilitate penetration of the CTO cap. Other CTO wires are designed with hydrophilic (slippery) tapered tips to enable advancement of the wire through microchannels that may be present along the length of the CTO. Support catheters specially designed to facilitate wire advancement through CTOs have also been refined. Finally, devices have been developed to aid reentry into the true lumen of the distal vessel for cases in which the wire has passed the CTO in a subintimal space.

Despite the fact that CTO percutaneous coronary interventions have been reserved thus far for patients with angina refractory to medical therapy, the interventional cardiologists at Oklahoma Heart Institute have extensive experience in this area because of the large overall volume of patients that are cared for here. Figures 5, 6, and 7 demonstrate procedural angiograms performed this year for several patients who were suffering from severe angina refractory to medical therapy and ultimately treated at Oklahoma Heart Institute with percutaneous coronary interventions of CTOs using the dual guide catheter technique. Using careful and meticulous techniques, excellent angiographic results were achieved in each of these patients.

In conclusion, percutaneous coronary intervention has evolved through numerous technical refinements to become an increasingly important treatment modality for an expanding proportion of patients with coronary artery disease. Although coronary CTOs are highly prevalent, percutaneous treatment has been reserved for severely symptomatic patients due to the challenging nature of these procedures. Recently published data suggests that successful CTO percutaneous coronary interventions may provide patients with improved survival in addition to symptomatic relief of their angina. These data combined with the technical advancements made in this field are likely to expand the role for percutaneous coronary intervention in the care and management of patients with coronary CTOs. The highly skilled interventional cardiologists at Oklahoma Heart Institute are well poised to treat the increasing number of patients who are likely to be referred for CTO percutaneous coronary intervention.

Raj H. Chandwaney, MD 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.
Process of patients suffering from severe angina refractory to medical therapy and ultimately treated at Oklahoma Heart Institute with percutaneous coronary interventions of CTOs using the dual guide catheter technique.

**Figure 5a**
Baseline angiogram of a right coronary artery CTO in a patient recently cared for at the Oklahoma Heart Institute.

**Figure 5b**
Dual guide catheter contrast injection. Collateral flow from the left coronary artery demonstrates the distal vessel (arrow) and reveals the true length of the CTO.

**Figure 5c**
Wire confirmation in the true lumen of the distal target vessel. Contrast injection via the left coronary catheter allows the operator to confirm the distal tip of the wire (arrow) is in the true lumen of the vessel.

**Figure 5d**
Balloon angioplasty (arrow) of the CTO.

**Figure 5e**
Final angiogram. Coronary angiogram performed after placing several stents in the right coronary artery reveals an excellent result.

**Figure 6a**
Baseline angiogram of a right coronary artery CTO in a patient recently cared for at the Oklahoma Heart Institute.

**Figure 6b**
Dual guide catheter contrast injection. Late collateral flow from the left coronary artery demonstrates the distal vessel (arrow) and reveals the true length of the CTO.

**Figure 6c**
Wire confirmation in the true lumen of the distal target vessel. Contrast injection via the left coronary catheter allows the operator to confirm the distal tip of the wire (arrow) is in the true lumen of the vessel.

**Figure 6d**
Balloon angioplasty (arrow) of the CTO.

**Figure 6e**
Final angiogram. Coronary angiogram performed after placing several stents in the right coronary artery reveals an excellent result.

**Figure 7a**
Baseline angiogram of a right coronary artery CTO in a patient recently cared for at the Oklahoma Heart Institute.

**Figure 7b**
Dual guide catheter contrast injection. Collateral flow from the left coronary artery demonstrates the distal vessel (arrow) and reveals the true length of the CTO.

**Figure 7c**
Wire confirmation in the true lumen of the distal target vessel. Contrast injection via the left coronary catheter allows the operator to confirm the distal tip of the wire (arrow) is in the true lumen of the vessel. Another parallel wire (dashed arrow) was initially placed in the right ventricular branch coronary artery to allow the operator to direct the second wire towards the true CTO.

**Figure 7d**
Balloon angioplasty (arrow) of the CTO.

**Figure 7e**
Final angiogram. Coronary angiogram performed after placing several stents in the right coronary artery reveals an excellent result.
Sleep Apnea: A Serious but Treatable Health Epidemic

By Michael Newnam, MD

Sleep apnea is a common medical problem with very significant health consequences. It is estimated that 42 million Americans have sleep apnea. Up to 90% of individuals with sleep apnea are unaware that they have this serious disorder. Sleep apnea contributes to the development of a variety of medical conditions including heart disease, atrial fibrillation, high blood pressure, diabetes, obesity, low testosterone and impotence (Figure 1). Sleep apnea significantly increases the risk of death from multiple causes, including sudden cardiac death and stroke. In addition, patients suffering with sleep apnea may experience excessive daytime sleepiness, greatly increased chance of traffic accidents, and poor focus and concentration. This article will cover the signs and symptoms of sleep apnea, the sleep evaluation process and the treatment options for sleep apnea.

Sleep apnea is an abnormal cessation of breathing while sleeping. The pause in breathing lasts at least 10 seconds but may last much longer. These episodes of apnea may occur from a few times per hour, up to more than one hundred times per hour. When breathing stops, the oxygen level declines, which results in stress and potential damage to multiple organ systems. There are two types of

Figure 1

Prevalence of Sleep Apnea in Comorbidities

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug-Resistant Hypertension</td>
<td>83%</td>
</tr>
<tr>
<td>Obesity</td>
<td>77%</td>
</tr>
<tr>
<td>Congestive Heart Failure</td>
<td>76%</td>
</tr>
<tr>
<td>Pacemakers</td>
<td>59%</td>
</tr>
<tr>
<td>Atrial Fibrillation</td>
<td>49%</td>
</tr>
<tr>
<td>Diabetes</td>
<td>48%</td>
</tr>
<tr>
<td>All Hypertension*</td>
<td>37%</td>
</tr>
<tr>
<td>Coronary Artery Disease*</td>
<td>30%</td>
</tr>
</tbody>
</table>

1. Logan et al J Hypertens 2001
2. O’Keeffe & Patterson, Circ Struc 2004
3. Oldenburg et al Eur J Heart Fail 2007
5. Gunn et al Circulation 2004
7. Sposnem et al Thorax 2002
8. Schaller Cardiology 1999

*Male subjects only
sleep apnea: obstructive and central. Obstructive sleep apnea (OSA) is a progressive narrowing of the airway during sleep until airflow is obstructed (Figure 2). This form of apnea frequently is associated with snoring, and an observer may hear the irregularities in the affected person’s breathing. When the oxygen level drops, the body senses the danger and forces an awakening from sleep, which many times results in a gasp or snort. The second type of sleep apnea is central sleep apnea, which is a cessation of breathing when there is no airway obstruction. In simple terms, the signal or drive to breathe is diminished even though the airway is open. This type of sleep apnea is less common than obstructive sleep apnea. Central sleep apnea is associated with heart failure, chronic pain medications, stroke and other neurologic diseases.

The sleep evaluation for sleep apnea consists of a thorough history and physical exam to identify risk factors, signs and symptoms, and comorbidities associated with sleep apnea (Figure 3). Since sleep apnea occurs during sleep, having a bed partner available to give their observations is helpful. Often the person suffering with sleep apnea doesn’t recall the frequent breathing difficulties or arousals from sleep. If sleep apnea is suspected, then an overnight sleep study (polysomnogram) should be ordered.

A polysomnogram or sleep study, as it is commonly called, is a way to monitor many important components of sleep and health during sleep. A series of belts and electrodes are placed on the head, chest and extremities in order to measure sleep architecture, heart rhythm, leg movements and respiratory parameters. To evaluate for sleep apnea, a breathing sensor is placed under the nose to measure airflow. A continuous pulse oximeter is placed on the finger to measure oxygen levels, and movement sensing belts are placed around the chest and abdomen to monitor breathing effort (Figure 4). With these monitors in place, any abnormal pauses in breathing can be detected.

In obstructive sleep apnea, airflow will be severely limited, but there will be continued efforts to breathe. In central sleep apnea, there also will be severely limited airflow, but there will be no respiratory effort.

If significant obstructive sleep apnea is identified during the sleep study, then a trial of treatment with CPAP is usually tried. CPAP stands for Continuous Positive Airway Pressure. This technology uses the principle of air pressure delivered by a nasal or full facemask to “split” the airway open (Figure 5). Since the air pressure keeps the airway open, normal breathing should resume. If time allows during the sleep study, a trial of CPAP is done after the diagnosis of obstructive sleep apnea is made. CPAP is started at a low pressure and gradually titrated until the airway remains open and breathing is normalized. If time is not sufficient to accomplish this in the first night’s sleep study, then a second sleep study is scheduled to allow enough time to find the best CPAP pressure. It is very important to find the correct CPAP pressure in order to effectively control obstructive sleep apnea.

Another important factor in assuring CPAP success is the selection of the right mask. CPAP masks come in a variety of styles and configurations. There are 3 basic types: nasal pillow mask, nasal mask and full facemask (Figure 6). Finding the right type of mask and getting the right size and fit is critical to success with CPAP therapy. An ill fitting mask is uncomfortable and will leak air. Many failed trials of CPAP therapy could have

Continued on p. 22
Obstructive sleep apnea is a very serious but treatable condition. Recognizing the signs and symptoms of OSA and seeking the appropriate evaluation for sleep apnea can be life saving.

SLEEP APNEA
Continued from p. 21

been avoided with the right mask.

An alternative treatment for obstructive sleep apnea is a custom oral appliance. An oral appliance has been proven effective for the treatment of mild to moderate obstructive sleep apnea. The oral appliance is custom made through a qualified dentist, who makes an impression of your teeth and sends the impressions to a fabrication facility for the appliance to be made (Figures 7 & 8). Once the oral appliance is formed, it has to be gradually titrated over several weeks until snoring and apnea are eliminated. An oral appliance works by moving your lower jaw (mandible) forward a few millimeters to physically “open up” the airway. A common adverse effect of wearing an oral appliance is jaw pain. Oral appliances are not indicated for severe obstructive sleep apnea.

Surgical procedures have also been used for many years to improve OSA. There are a variety of types of sleep apnea surgeries including nasal septum and turbinate surgery, surgeries to remove tissue in the back of the pharynx and palate, and tongue and jaw advancement procedures. Although these surgeries can be successful for improving obstructive sleep apnea, they are not typically the first choice for treatment. The one exception to this rule is in children where anatomical obstruction from tonsils and adenoids is commonly the root cause of their sleep apnea. For children, adenotonsillectomy is considered first-line therapy for sleep apnea.

Treatment for sleep apnea is often very successful and usually makes a dramatic difference in both sleep quality and daytime alertness. Once there is restoration of normal breathing, many parameters of health improve. Blood pressure and heart rate improve within the first few weeks of therapy. Metabolism and blood sugars improve, and weight loss often occurs. Studies show significant improvement in cardiac function and a major reduction in heart arrhythmias. Successful treatment of atrial fibrillation has been consistently linked with adequately treating sleep apnea.

Obstructive sleep apnea is a very serious but treatable condition. Recognizing the signs and symptoms of OSA and seeking the appropriate evaluation for sleep apnea can be life saving. If you or someone you know has the symptoms, inform your primary physician and seek a sleep evaluation.

Michael B. Newnam, MD 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.

PTCA TREATMENT FOR TOTAL OCCLUSIONS
Continued from p. 18

References


What to expect during a sleep study:
- A warm welcome by highly qualified technicians
- An informal orientation during which the sleep study process will be explained, and you will have an opportunity to ask questions
- A comfortable, stylish and luxurious bedroom featuring:
  - Queen sized, luxury bed with pillows
  - 300+ thread count sheets
- A continental breakfast in the morning

Oklahoma Heart Institute now offers comprehensive sleep care at our new diagnostic facility located in Columbia Plaza:

2651 E. 21st Street, Suite 400
Tulsa, OK 74114
Phone: 918.747.5337 (918.74 SLEEP)
Toll Free: 855.437.5337 (855.43 SLEEP)
Fax: 918.728.3307

The facility features 6 beds, and operates most nights per week.
For 25 years, at Oklahoma Heart Institute we’ve known that living well takes a healthy heart. That’s why our 41 specialists are dedicated to diagnosing and treating cardiovascular, metabolic and sleep problems with a team approach and unmatched, advanced technology. We tackle even the most difficult problems, so you can get better results.

When you need complete heart care, trust the doctors of OHI. We have what it takes so you can live well. Our patients are living proof.

TECHNOLOGY AND KNOW-HOW FOR RESULTS YOU CAN DEPEND ON.