Oklahoma Heart Institute

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Critical Limb Ischemia: A Case Based Discussion

Transcatheter Closure of PFOs to Prevent Strokes

Secondary Mitral Regurgitation: The COAPT Trial

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features

ON THE COVER
Oklahoma Heart Institute (the Heart Hospital) at sunset.
Photo by Tyler Lane

to our readers

This issue of Oklahoma Heart Institute magazine focuses on newer treatment strategies for treating serious cardiovascular problems.

The association between a patent foramen ovale (PFO) and "cryptogenic" stroke has been known for decades. The first article reports on four randomized clinical trials that show the efficacy of percutaneous, transcatheter closure of PFOs and demonstrate that closure of PFOs significantly reduces the risk of subsequent strokes.

Peripheral arterial disease (PAD) is a very common problem and is associated with significant morbidity, including amputations, and is also associated with increased mortality. Dr. Chandwaney discusses how newer catheter based techniques are now providing effective treatment for patients previously felt to be not treatable.

Advances in transcatheter mitral valve repair (Mitra Clip) now provide effective therapy for previously untreatable patients with significant mitral regurgitation and heart failure. Dr. Kaneshige discusses the recently released results of the COAPT Trial showing the dramatic benefit of transcatheter mitral valve repair (Mitra Clip) for these patients.

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

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

Transcatheter Closure of PFOs to Prevent Strokes

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

Figure 1

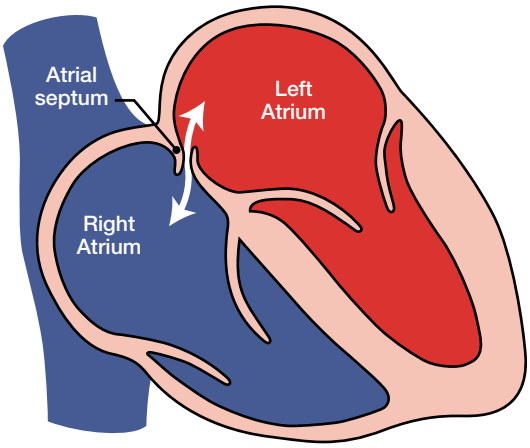


Figure 2

Transcatheter PFO Occluders

GORE® CARDIOFORM

AMPLATZER™ PFO OCCLUDER

The recognition of an association between "cryptogenic" strokes and the presence of a PFO (Patent Foramen Ovale) was made many years ago. Recently, four randomized clinical trials have shown that closing the PFO in the cath lab using percutaneous, transcatheter techniques reduces the risk of strokes compared to medical therapy with antiplatelet or anticoagulation therapy (1, 2, 3, 4, 5).

WHAT IS A PFO?

A patent foramen ovale (PFO) is a remnant of embryological development. By the 7th week of gestation, the septum primum and the septum secundum (both membranes separating the left and right atrium) are kept apart from each other by difference in right-and left-sided pressures. They create a tunnel for unidirectional right to left shunting of blood from the inferior vena cava (IVC) to the left atrium (Figure 1). At birth, the inter-thoracic and inter-cardiac pressures change with the use of the lungs for oxygenation of the blood. Because of the changes in inter-cardiac pressure, the two membranes come together and the tunnel closes. In most people, the membranes fuse together permanently, closing the atrial septum to further shunting.

However, in 20% to 25% of the population the membranes come together but fail to fuse after delivery. The result is that the membranes can intermittently come apart with changes in the right sided pressures, such as with coughing or Valsalva maneuvers. This allows for intermittent shunting as the membranes come apart. Therefore, a PFO is not a true hole in the heart (such as an atrial septal defect (ASD), but an intermittent tunnel that allows for intermittent right to left shunting across the intra-atrial septum. The amount of shunting depends on the size of the tunnel and whether there is excess tissue producing a mobile intra-atrial septum or atrial septal aneurysm.

The reason for concern about PFOs is that they are a potential cause of paradoxical emboli, which could produce strokes, heart attacks, or other systemic embolic events. A paradoxical embolus is when a blood clot formed in the venous circulation gets pumped into the arterial circulation (i.e. via the PFO) and then travels to an organ (such as the brain) where it occludes blood flow to that organ.

WHAT IS A CRYPTOGENIC STROKE?

Strokes rank as the 4th leading cause of mortality in the United States and the leading cause of disability. Almost 800,000 strokes occur annually in the United States. Approximately 87% of strokes are ischemic strokes in which blood flow to the brain is blocked, causing damage to the brain (versus hemorrhagic strokes where there is a bleed into the brain).

Of the ischemic strokes, 15% to 20% are thought to be embolic due to cardiogenic emboli. The most common cause of cardioembolic strokes is atrial fibrillation. It is this reason that patients with atrial fibrillation are treated with anticoagulants.

Despite extensive investigation as to the cause of a stroke, between 20% to 30% of ischemic strokes have no clearly identifiable pathogenesis, and are called cryptogenic strokes (strokes without an identifiable cause). Data suggests that a significant number of cryptogenic strokes may be due to paradoxical emboli from patent foramen ovale (PFOs). Nearly half of people who suffer a cryptogenic stroke have a PFO, as compared to the 20% to 25% prevalence of PFOs in the general adult population.

The association of PFOs and cryptogenic strokes leads to two treatment strategies for patients with PFOs and cryptogenic strokes. The first strategy is medical therapy consisting of anti-coagulating the patient to prevent the formation of blood clots. The second strategy is to close the PFO with a device

so blood clots cannot pass through the PFO into the arterial circulation, causing a stroke or other systemic embolic event.

STUDIES SHOWING THE EFFECTIVENESS OF CLOSING PFOS AS COMPARED TO MEDICAL THERAPY

Four randomized clinical trials have demonstrated the effectiveness of transcatheter closure of PFOs for the prevention of strokes. The long-term outcomes of patent foramen ovale closure versus medical therapy with anti-clotting medications in patients who had a cryptogenic stroke (RESPECT-Trial) was published in the New England Journal of Medicine in September of 2017, along with two other randomized trials looking at the same issues.[2]

The RESPECT-Trial enrolled 980 patients, ages 18 to 60 years old, who had a previous cryptogenic stroke and a PFO, and randomized them to undergo closure of the PFO (PFO Closure Group) or to receive medical therapy, consisting of aspirin, or warfarin, or clopidogrel, or aspirin plus clopidogrel or aspirin combined with dipyridamole (Medical Therapy Group). The median follow up time was 5.9 years. This study used the Amplatzer PFO Septal Occluder Device (Figure 2).

By the intention-to-treat analysis, there was a significant 45% reduction in recurrent ischemic strokes in the PFO closure group as compared to the medical therapy group (Figure 3). The benefit was greater based on the per-protocol analysis since 3 patients in the PFO Closure Group had their strokes before they got their device placed (Figure 4).

Subgroup analysis of the results found a greater risk reduction with PFO closure as compared to medical therapy among patients with atrial septal aneurysms and those patients with large amounts of right to left shunting.

The CLOSE-Trial was also published in 2017, and it showed that among patients with recent cryptogenic strokes attributed to a PFO, there was a significant reduction in the rate of recurrent strokes in the PFO closure group as compared to those assigned to medical therapy consisting of antiplatelet therapy alone.[3] This study included only patients with PFOs that were considered high risk PFOs (associated with either an atrial septal aneurysm or they demonstrated large inter-atrial shunting). This trial used a variety of different closure devices.

A total of 663 patients were enrolled in the CLOSE-Trial. They were randomized to PFO closure plus antiplatelet therapy versus dual antiplatelet therapy alone versus oral anticoagulation. They were followed for a mean of 5.3 years.

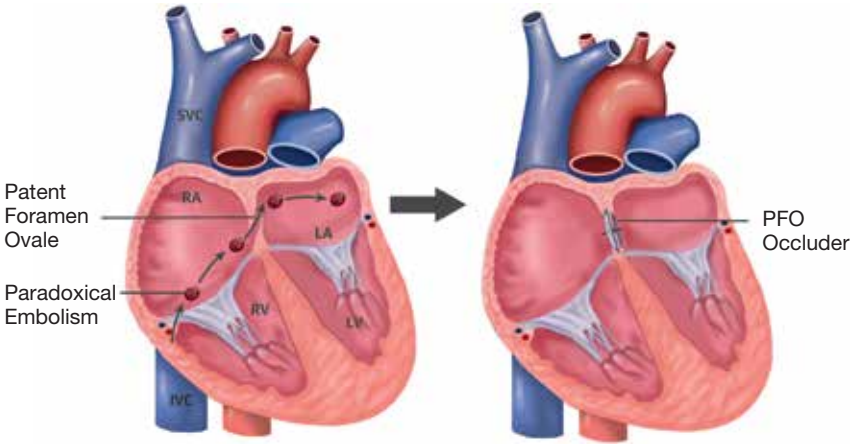
There were no subsequent strokes in the PFO closure group. There were 14 patients in the antiplatelet group that had a stroke. Stroke occurred in three patients in the anticoagulation group. The Kaplan-Meier five-year cumulative estimate of the probability of a stroke was 4.9% in the antiplatelet group.

The REDUCE-Trial, evaluated the Gore Closure Device for the prevention of subsequent ischemic strokes in patients with PFOs and cryptogenic stroke.[4] This trial randomized 664 patients of whom 81% had moderate to large inter-atrial shunts. They were randomized to either PFO closure with antiplatelet therapy (PFO closure group) or to antiplatelet therapy alone

(continued on p. 6)

Figure 3

Percutaneous Device Closure of a PFO After Cryptogenic Stroke

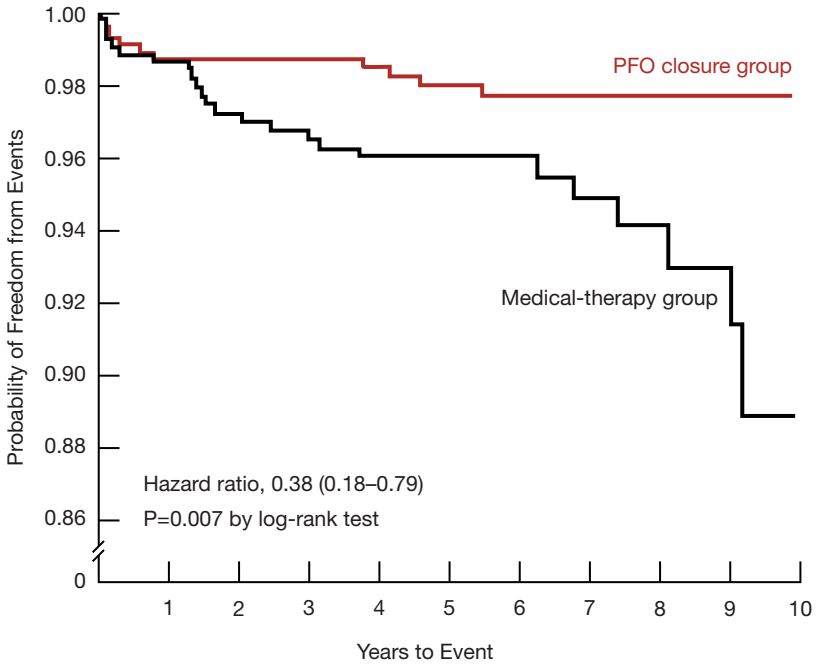


Paradoxical embolism traveling through a patent foramen ovale (PFO) via the right-to-left blood flow. Amplatzer PFO Occluder is in place after a percutaneous closure.

IVC = inferior vena cava; LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle; SVC = superior vena cava

Figure 4

Recurrent Ischemic Strokes of Undetermined Cause



Continued from p. 5

(antiplatelet-only group).

During a median follow up of 3.2 years, clinical ischemic strokes occurred in 1.4% of the PFO closure group and in 5.4% in the antiplatelet-only group, which represented a 77% relative risk reduction for the PFO closure group.

In this study, the number of patients with a PFO and a previous cryptogenic stroke needed to be treated with a closure device to prevent one stroke in 24 months was 28 patients.

The DEFENSE-PFO trial randomized only 120 patients because the study was stopped early due to publishing the beneficial results seen with closing PFOs in the previously discussed trials.[5]

The study randomized patients with cryptogenic strokes and high risk PFOs (defined as presence of an atrial septal aneurysm or hyper mobility of the atrial septum or separation of the septal membranes by ≥ 2mm). The primary endpoint of the study was a composite of stroke, vascular death, or major bleeding during the follow up of two years.

In the DEFENSE-PFO-Trial, no primary endpoints occurred in the PFO closure group. A 12.9% two-year event rate occurred in the medication groups (antiplatelet therapy or warfarin anticoagulation). In this study, only ten patients needed to be treated with the closure device to prevent one stroke at two years.

SAFETY OF TRANSCATHER PFO CLOSURES

A meta-analysis of five randomized clinical trials involving PFO closure devices found a small, significant increase in the risk of atrial fibrillation in the PFO closure groups.[6] The risk was somewhat device dependent. Most cases of atrial fibrillation occurred early (<45 days) after implantation and only 3.8% of post closure atrial fibrillation episodes reportedly progressed to permanent atrial fibrillation.

There have been rare cases of problems from nickel allergy with the devices. A small risk of significant bleeding at the access sites was also reported. Safety results from the clinical trials showed no significant differences in the all cause serious adverse events rates when comparing PFO closure with medical therapy.

HOW IS A PFO DIAGNOSED?

Screening for a PFO is often done with a transthoracic echocardiogram (TTE). The sensitivity of transthoracic echocardiography is about 46%. Transesophageal echocardiography (TEE) is better at detecting PFOs and can distinguish between a PFO and an ASD (which are closed with a different device). A TEE can also identify higher risk features associated with paradoxical embolic events such as intra-atrial aneurysms, mobile intra-atrial septums, and the degree of right to left shunting.

A transcranial Doppler is the most sensitive non-invasive test for detecting a PFO and also for quantifying the magnitude of right to left shunting. A right heart catheterization demonstrating a guide wire across the atrial septum confirms the presence of a PFO.

CLOSING A PFO

Most PFOs are closed by a transcatheter technique done in the cardiac catheterization lab. The Amplatzer PFO Septal Occulder Device and the Gore Cardioform Septal Occulder Device are the devices are currently approved for use in the United States (Figure 3).

The procedure is done with conscious sedation with both X-ray and Intracardiac Echo (ICE) guidance. Access is usually via the femoral vein in the groin.

At Oklahoma Heart Institute, the patient is usually monitored in the hospital overnight for any dysrhythmias or bleeding complications. The patient is placed on aspirin and clopidogrel 75 mg a day to prevent thrombus from forming on the device. Currently, we recommend six months of dual antiplatelet therapy and then the clopidogrel is stopped, and the patient remains on a baby aspirin thereafter. Some studies used shorter durations of dual antiplatelet therapy.

Patients are treated with SBE (subacute bacterial endocarditis) prophylaxis for six months to prevent device infection. Patients are instructed on a reduced activity level for the first 30 days post implantation to prevent device embolization. Follow up echocardiograms are done within the first six months to assess the stability and effectiveness of the closure result, and an echo is done at one year to make sure there are no late complications, such as erosions with larger devices. Patients can have MRIs and go through airport screenings with PFO closure devices.

CONCLUSION

Stroke remains a leading cause of death and disability. Nearly ½ of patients with cryptogenic strokes have a PFO. Recent randomized trials show that transcatheter closure of the PFO in these patients produces a significant reduction in subsequent strokes as compared to medical therapy. This benefit is even greater in patients with PFOs associated with a mobile intra-atrial septum, or an atrial septal aneurysm, or moderate to large degrees of right to left shunting. There remains the question as to whether a doctor must wait for a patient to suffer a stroke before the higher risk PFOs are closed.

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.

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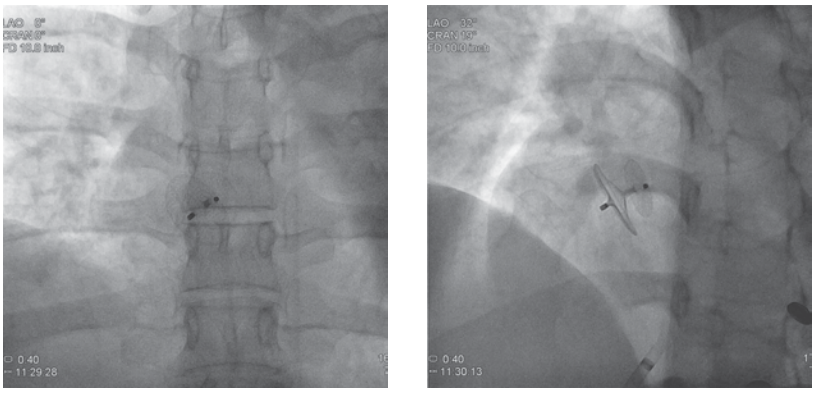
Figure 5



Critical Limb Ischemia:

A Case Based Discussion

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

Critical limb ischemia (CLI) is a clinical syndrome of ischemic rest pain or tissue loss such as gangrene or ulcerations due to obstructive peripheral artery disease. Critical limb ischemia differs from acute limb ischemia, which is a sudden loss of limb perfusion (less than 14 days by definition). In contrast, critical limb ischemia occurs over weeks to months.

The Rutherford and Fontaine classification systems are used to categorize patients with peripheral artery disease (see figure 1).[1] The nomenclature allows clinicians to communicate the severity of illness that patients with peripheral artery disease present with. It is noteworthy that patients with critical limb ischemia represent the sickest patients with peripheral artery disease, as they are labeled as Rutherford classes 4, 5, or 6, and as Fontaine classes III, or IV.

Of great concern is that patients presenting with critical limb ischemia have a risk of major amputation (defined as above the ankle) that occurs in 30-50% of patients within one year without revascularization.[1] Avoiding major amputations whenever possible is paramount because major amputations are associated with significant functional limitations and lead to increased morbidity and mortality in CLI patients. On the other hand, minor amputations (defined as toe or forefoot) are often required to treat tissue loss and usually do not limit functional independence significantly.

Despite the adverse outcomes that occur with major amputation in CLI patients, a recent study demonstrated that from 2000-2010, only 38.7% of Medicare beneficiaries underwent an invasive angiogram prior to lower extremity amputation.[2] Because of the large number of patients that proceed to amputation without ever undergoing evaluation for revascularization, protocols to more aggressively evaluate patients for peripheral artery disease with signs of CLI have been proposed in the medical literature. An example of one such algorithm is demonstrated in figure 2.[3] There are several important issues that this algorithm brings forth that should be highlighted.

First of all, this algorithm (figure 2) emphasizes the need to visually define the extent of peripheral artery disease in patients with poorly healing wounds or ischemic rest pain. Due to pressure amplification that can occur with stiff, or calcified arteries, ankle brachial indices are often misleading in CLI patients. A normal ankle brachial index does not rule out obstructive peripheral artery disease in these patients. In a recently published study, 25% of CLI patients referred for endovascular intervention were noted to have a normal ankle brachial index, and 19% of CLI patients referred for surgical revascularization were noted to have a normal ankle brachial index.[4] Although, the algorithm suggests that CT angiography, MR angiography, or invasive angiography could be performed, the majority of CLI patients will require invasive angiography because the smaller infrapopliteal arteries are often suboptimally visualized using noninvasive techniques.

The second issue of importance illustrated by

(continued on p. 8)

Figure 1

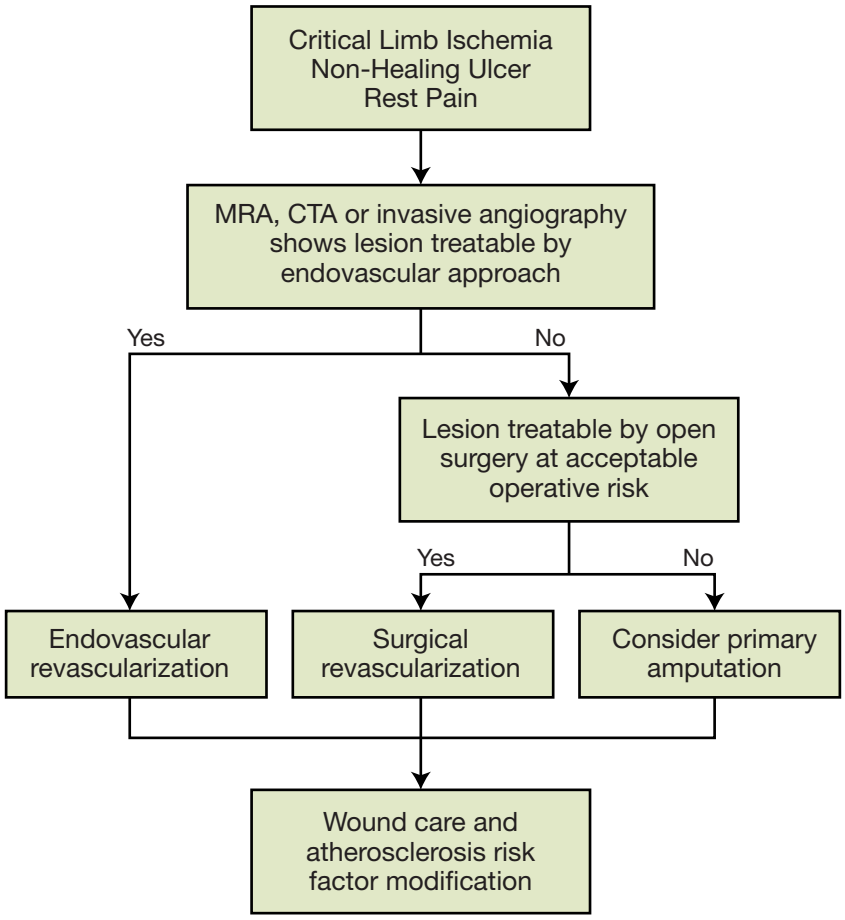
Rutherford and Fontaine classifications for peripheral artery disease severity

	Symptom Complex	Rutherford Classification	Fontaine Classification
	Asymptomatic	Stage 0	Stage 1
Intermittent claudication	Mild claudication	Stage 1	Stage IIA (symptoms with >200-m walking)
	Moderate claudication	Stage 2	Stage IIB (symptoms with <200-m walking)
	Severe claudication	Stage 3	
Critical limb ischemia	Rest pain	Stage 4	Stage III
	Ischemic ulceration (limited to digits)	Stage 5	Stage IV
	Severe ischemic ulceration or frank gangrene	Stage 6	

TASC II Working Group. Int Angiol. 2007; 26: 81-157

Figure 2

An algorithmic approach to manage patients with critical limb ischemia



Circ. Cardiovasc. Interv. 2016; 9: e001946

Continued from p. 7

the algorithm (figure 2) is that endovascular revascularization is favored over surgical revascularization in patients presenting with CLI. Randomized studies examining the outcomes of CLI patients with endovascular versus surgical revascularization are scarce. The BASIL trial, which is considered the landmark study in the field, demonstrated similar rates of amputation-free survival during 4 years of follow up (see figure 3).[5] An additional observation noted in the BASIL trial was a higher number of periprocedural complications such as myocardial infarctions, strokes, and deaths in patients treated with surgical revascularization compared to endovascular revascularization (see figure 4).[5] This observation is due to the fact that many patients presenting with CLI also have concomitant advanced coronary artery disease and/or cerebrovascular disease that may not yet be diagnosed at the time they present with CLI.

The third issue of importance illustrated by the algorithm (figure 2) is that if the patient is initially deemed a poor candidate for endovascular revascularization, the patient's operative risk needs to be evaluated before proceeding with surgical revascularization. As suggested above, many patients with CLI have undiagnosed, but advanced, coronary artery disease and/or cerebrovascular disease that may ultimately prohibit surgical revascularization. These patients may require primary amputation. As directed by the algorithm, patients who are at a high risk for surgical complications, should be reconsidered for endovascular intervention, perhaps by a more aggressive operator. This aspect of the algorithm emphasizes the need for endovascular specialists who treat patients with CLI to perform at the highest technical level.

Finally, it should be noted that treatment algorithms for the management of patients with CLI will evolve as further research continues. The National Heart, Lung, and Blood Institute (NHLBI) sponsored BEST-CLI trial is expected to enroll approximately 2100 patients with CLI.[6] The trial will randomize patients to endovascular or surgical revascularization, and is expected to provide the medical community with valuable new insights for the treatment of CLI patients using contemporary techniques. Of particular interest will be the knowledge that is gained regarding the hypothesis that angiosome targeted revascularization is required to achieve limb salvage. This hypothesis suggests that operators must achieve revascularization in the infrapopliteal vessel that provides blood flow directly to the area of the leg where the ulceration is located (see figure 5).[3] Thus far, smaller studies and the experience of most proficient operators suggest that achieving single vessel runoff to the foot in any angiosomal distribution will prevent major amputations in most patients.

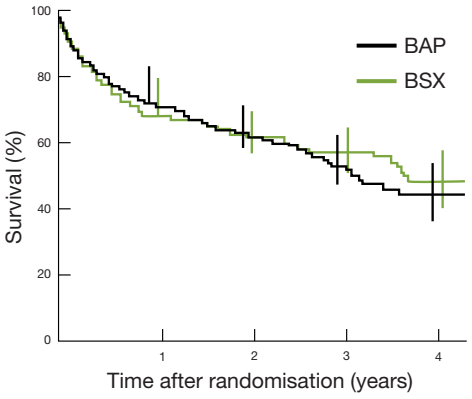
CASE EXAMPLES

CASE 1

A 60-year-old woman was referred to Oklahoma Heart Institute for a second opinion by her wound care specialist because of a long-standing ischemic ulceration on the plantar surface of the right first toe. The patient was originally referred to another vascular specialist who suggested that angiography not be performed because of a normal ankle brachial index, and because the patient had significant renal insufficiency. Ultimately, we elected to proceed with angiography. The majority of the angiogram was performed using CO2 angiography to visualize the iliac, femoral and popliteal arteries that were found to only have mild luminal irregularities. To adequately visualize the infrapopliteal arteries, a total of 6 mL of a contrast was required. The angiogram revealed a critical stenosis in the distal segment of the posterior tibial artery that corresponded to the angiosomal distribution of the ischemic ulceration (figure 6a). Angioplasty was performed and an excellent angiographic result was achieved (figures 6b and 6c). The patient's ulcer healed within the next several weeks. This case il-

Figure 3

The landmark BASIL trial demonstrated similar rates of amputation-free survival with endovascular (BAP) and surgical (BSX) revascularization



Lancet. 2005; 366: 1925-1934

Figure 4

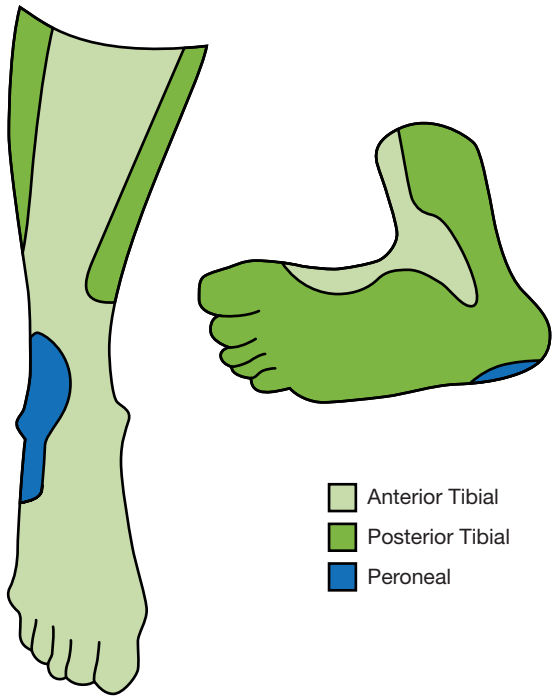
An additional observation noted in the BASIL trial was a higher number of periprocedural complications (myocardial infarctions, strokes, and deaths) in patients treated with surgical revascularization compared to endovascular revascularization

	During same hospital stay as first intervention	
	Angioplasty (n=237)	Surgery (n=197)
Mortality	7	11
Morbidity		
Angina	4	4
Myocardial infarction	6	13
Stroke	1	3

Lancet. 2005; 366: 1925-1934

Figure 5

Angiosome distributions showing regions supplied by each of the infrapopliteal arteries



Circ. Cardiovasc. Interv. 2016; 9. e001946

lustrates the importance for endovascular specialists to possess the skills needed to perform distal infrapopliteal interventions, and to have a familiarity with alternative imaging modalities such as CO2 angiography for patients with renal insufficiency, which is a common comorbidity in patients presenting with CLI.

CASE 2

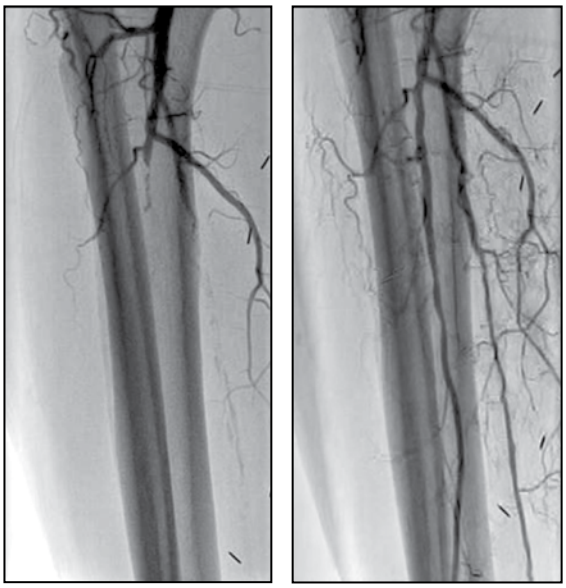
A 72-year-old man was referred for a poorly healing right heel ulceration and a gangrenous fifth toe. An initial angiogram performed via a left femoral artery access site revealed no significant disease of the right iliac, femoral, or popliteal arteries. All three of the infrapopliteal arteries were found to be chronically occluded (figure 7a). Initial attempts to cross the chronic total occlusions via the contralateral left femoral approach were unsuccessful. The patient was scheduled for a reattempt 1 week later. To optimize chances for successful crossing of a chronic total occlusion, antegrade access was obtained in the right femoral artery. By maximizing support and pushability with antegrade access, the chronic total occlusions in the posterior tibial and peroneal arteries were successfully crossed and treated with coronary drug eluting stents to maximize durability of the final result (figure 7b). The patient did require a minor amputation of the gangrenous fifth toe but his right heel ulcer heeled well. This case illustrates the importance for endovascular specialists to have experience using alternative access sites that may be required to achieve success with more challenging anatomical situations such as infrapopliteal chronic total occlusions. This case also prompts operators to be reminded of the results of the DESTINY trial that demonstrated the long-term benefits of using coronary drug eluting stents to treat infrapopliteal disease when practical (figure 8).[7]

CASE 3

A 79-year old-woman with severe chronic lung disease was referred for further management of ischemic rest pain in the left lower extremity. Angiography of the left iliac, and femoral ar-

(continued on p. 19)

Figure 7



(A) Angiogram demonstrates chronic total occlusions of all three infrapopliteal arteries.

(B) Final result after treating the posterior tibial and peroneal arteries with coronary drug eluting stents.

HAVE A BLANKET DATE

Sure, you could spend a Saturday at home with a pizza box on your lap and call it a "date." There's nothing wrong with that, but you *could be* just as seriously relaxed outside in a park on a blanket with really good food (like, olives and prosciutto good). Call it a #blanketdate.

If putting in effort doesn't jive with your summer vibes, don't worry. Just swing by Whole Foods Market on your way to the park and grab the good stuff!

FOR STARTERS Meat, Cheese and More

Let's be honest for a minute: The appetizers are just as good as the main course. Live by that rule, and start your meal off with some antipasto.

Try Divina Olympia Provisions Antipasto Mix – an olive salad featuring Asiago and Olympia Provisions Salami Cotto, which you can pick up at the olive bar. Couple that with an easy meat and cheese plate. Try some thinly sliced Principe Prosciutto di Parma long with some Black Creek Cheddar, an aged Wisconsin cheddar that's sharp enough to stand up to the salty tang of the olives. It pairs well with a spicy mustard. If you want something sweet, a bit of fruit is always a nice pairing for prosciutto – try some melon or some strawberries.

NEXT UP A Classy Assembly of Veggies and Dips

… aka crudités, but let's call it crudités on summer vacation. It can be just as easy as chips and guac. The picnic version skips the cutting-the-vegetables step by subbing in precut vegetables and rich, creamy dips to go with them.

THE MAIN EVENT Fried Chicken *(..or something else)*

Fried chicken is a classic picnic dish because it tastes just as great cold as it does hot. But … it's also kind of a pain to make. Let Whole Foods do the frying. Pick yours up and be ready to go. (Availability varies by location.) If you're not in a fried chicken mood, ready-made chicken salad (or grilled chicken in the deli) is a great alternative. Serve it with crackers, on bread or even with salad greens. As for sides, there is plenty to choose from in the prepared foods section, including great pasta salads, tabbouleh, deviled eggs … pretty much whatever suits your fancy!

DESSERT Pie (of course)

The real dream date here is between you and pie. We suggest pie, not only because a good pie makes for a solid, Instagrammable picnic centerpiece, but also because pie makes everything better in general. You don't even have to bake it! Pick up an apple or cherry pie and remember to bring some sort of utensil for cutting and serving! Pie goals? Check.

#treatyourself

Whether you're going on a family adventure, hanging out with a good friend, or enjoying the sun on your own, you deserve to #treatyourself without having to stress or spend hours in the kitchen. So fold up the blanket, pack up the picnic basket – or backpack – and get ready to head to the park for a delicious blanket date!

ZUCCHINI NOODLES WITH ALMOND PESTO

Serves 4

This simple dish uses just five ingredients to achieve a fresh and bright pasta-salad substitute by employing zucchini "noodles" (made using a vegetable peeler!) as a delicious stand-in. The noodles make a fantastic side, or top them with shrimp, white beans or smoked tofu for a light summer main course.

3 small zucchini (about 1 1/4 pounds total), ends trimmed
1/2 cup roasted, unsalted whole almonds
1 1/4 cup loosely packed fresh basil leaves, divided
1 tablespoon sherry vinegar
1/4 teaspoon fine sea salt

Using a vegetable peeler, remove long strips from 1 zucchini and place in a bowl; when you reach the soft, seedy core, place it in a food processor. Repeat with remaining zucchini. Refrigerate zucchini "noodles."

Add almonds, 1 cup of the basil, vinegar and salt to the food processor with zucchini cores. Pulse, scraping down sides of the food processor frequently, until a chunky purée forms. Toss noodles with almond pesto. Slice remaining 1/4 cup basil and sprinkle on top.

WATERMELON AGUA FRESCA Serves 6

This light, refreshing drink popularized in Mexico, is a terrific thirst quencher on a hot summer day. The trick to making agua fresca (Spanish for "fresh water") is to infuse the water with fruit essence without turning it into a smoothie or a slushy drink.

6 pounds seedless watermelon, cut into 2-inch pieces
1 tablespoon lime juice
1 tablespoon agave nectar or honey
Ice cubes, for serving

In a blender, combine half of the watermelon and 1 cup cold water and blend until smooth. Pour through a strainer into a pitcher; discard solids. Repeat with remaining watermelon and 1 cup cold water. You should have about 8 cups juice. Stir in lime juice and agave and refrigerate for at least 1 hour. Serve well-chilled over ice.

SUMMER PRODUCE

Vegetables

Arugula, Beans, Beets, Bell Peppers, Broccoli, Cabbage, Carrots, Cauliflower, Celery, Collard Greens, Corn, Cucumbers, Eggplant, Garlic, Green Beans, Green Peas, Onions, Potatoes, Radishes, Radicchio, Spinach, Summer Squash, Swiss Chard, Tomatoes, Zucchini

Fruits

Apples, Apricots, Avocado, Bananas, Blackberries, Blueberries, Cantaloupe, Cherries, Figs, Melons, Nectarines, Peaches, Plums, Rasberries, Rhubarb, Strawberries, Watermelon

Oklahoma Heart Institute

SERVICES

www.oklahomaheart.com

Interventional Cardiology
- Cardiac Catheterization
- Coronary Angioplasty
- Coronary Stents
- Multivessel Angioplasty and Stenting
- Atherectomy
- Rotablator Atherectomy
- Thrombolytic Therapy
- Carotid Stenting
- Fractional Flow Reserve
- Intravascular Ultrasound
- Intracardiac Echo
- Paravalvular Leak Plugs
- Myocardial Biopsy
- Pericardiocentesis
- Peripheral Angioplasty
- Peripheral Stents
- Percutaneous ASD Closures
- Percutaneous PFO Closures
- Impella Circulatory Support
- Therapeutic Hypothermia for Cardiac Arrest Patients
- Transcatheter Aortic Valve Replacement (TAVR)
- Transcatheter Mirtral Valve Repair
- Venous Ablation
- Aspiration Venous Thrombolic Obstructive Disease

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
- 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	Oklahoma Heart Institute at Utica Physicians Offices	Oklahoma Heart Institute at South Pointe Physicians Offices	Oklahoma Heart Institute At Hillcrest Hospital South
1120 S. Utica Avenue Tulsa, OK 74104 P) 918.574.9000	1265 S. Utica Avenue Tulsa, OK 74104 P) 918.592.0999 • F) 918.595.0208	9228 S. Mingo Road Tulsa, OK 74133 P) 918.592.0999 • F) 918.878.2408	8801 S. 101st E. Avenue Tulsa, OK 74133 P) 918.592.0999

THE DOCTORS OF OKLAHOMA HEART INSTITUTE

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

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

Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

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

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

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

James J. Nemec, MD, FACC

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

Board certified in Internal Medicine, Cardiovascular Disease and Nuclear Cardiology

Gregory D. Johnsen, MD, FACC, FSCAI

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

Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

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

Dr. Kaneshige is a noninvasive cardiologist with expertise in adult echocardiography, stress echocardiography and transesophageal echocardiography. He is 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, FSCMR

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. He has been the principal investigator in many clinical research trials and authored numerous peer-reviewed manuscripts and book chapters. 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 also a past ACC Governor of the State of Oklahoma. He is also a two-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 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, ECNU
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 complex ablation, atrial fibrillation management, pacemakers, implantable defibrillators, cardiac resynchronization devices, and lead management and left atrial appendage closure. Dr. Cameron is Director of Electrophysiology at Hillcrest Hospital South. He completed his Cardiac Electrophysiology Fellowship and his Cardiovascular Disease Fellowship at Baylor University Medical Center in Dallas, TX. Dr. Cameron's Internship and Internal Medicine Residency were performed at Baylor College of Medicine in Houston. He earned his medical degree from the University of Kansas School of Medicine in Kansas City, KS. Dr. Cameron received his Bachelor of Science degree at Pittsburg State University in Pittsburg, KS.
Board certified in Cardiovascular Disease and Cardiac Electrophysiology

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

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

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

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

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

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

Jana R. Loveless, MD

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

Board Certified in Internal Medicine and Sleep Medicine

Mathew B. Good, DO, FACC, RPVI

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

Board certified in Internal Medicine and Cardiovascular Computed Tomography

Stanley K. Zimmerman, MD, FACC, FSCAI

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

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

Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

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 in Thoracic and General Surgery

James B. Chapman, MD, FACC, FSCAI

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

Board certified in Internal Medicine, Cardiovascular Disease and Interventional Cardiology

Joseph J. Gard, MD, FACC, FHRS

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

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

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.

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

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, Echocardiography and Heart Failure.
Board eligible in Nuclear Cardiology. Board eligible in Advanced Heart Failure and Transplant

Mrudula R. Munagala, MD, FACC

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

Board Certified in Internal Medicine, Cardiovascular Diseases, Heart Failure and Transplant, Echocardiography and Nuclear Cardiology

Siva Soma, MD, FACC, FHRS

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

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

Dr. Soma completed a Master's degree in public health from West Virginia University and received his medical degree from Armed Forces Medical College in India.

Board certified in Internal Medicine, Cardiovascular Disease and Nuclear Cardiology

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

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

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

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

Board certified in Thoracic and General Surgery

Allen Cheng, MD

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

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

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

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

Dr. Cheng serves as the Surgical Director of Advanced Heart Failure and Mechanical Circulatory Support at Oklahoma Heart Institute.

Board certified in Surgery and Thoracic Surgery

Shahid Qamar, MD, FACC

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

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

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

Board Certified in Internal Medicine and Cardiology

Adel M. Barkat, MD, RPVI

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

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

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

Hoda Butrous, MD

Dr. Butrous is an Advanced Heart Failure and Transplant specialist at Oklahoma Heart Institute, with expertise in managing advanced heart failure and pulmonary hypertension, including the evaluation and treatment of patients needing Mechanical Circulatory Support (LVAD).

She performed an Advanced Heart Failure and Cardiac Transplant Fellowship at the University of Utah School of Medicine in Salt Lake City, Utah and completed her Cardiology Fellowship at Beaumont Hospital in Dearborn, Michigan.

Dr. Butrous completed her Internal Medicine Residency at the Loma Linda University Medical Center in Loma Linda, California. She earned her medical degree at Benha Medical School, Benha University, Egypt.

Board certified in Cardiovascular Disease and Internal Medicine

Adel E. Ghuloom, MD

Dr. Ghuloom is a Cardiovascular Critical Care Intensivist at Oklahoma Heart Institute, with expertise in advanced heart failure, including mechanical circulatory support (LVAD and ECMO) and heart transplant cardiovascular intensive care.

He performed a Fellowship in Critical Care at Baylor College of Medicine in Houston TX. Dr. Ghuloom completed his Internal Medicine Residency at Wayne State University in Detroit, MI.

He earned his medical degree at Arabian Gulf University, Manama, Bahrain, where he also received his Bachelor of Science Degree. Prior to joining Oklahoma Heart Institute, he was a Cardiovascular Critical Care specialist at Tufts University.

Board certified in Critical Care and Internal Medicine

Wendell E. Williams, MD

Dr. Williams is a cardiologist at Oklahoma Heart Institute who specializes in the evaluation, diagnosis, treatment and education of congestive heart failure, coronary artery disease, hypertension and high cholesterol. He completed a Cardiovascular Fellowship at St. Luke's Episcopal Presbyterian Hospital in Chesterfield, Missouri Dr. Williams performed his Internal Medicine Internship and Residency Programs at Washington Hospital Center in Washington, D.C.

Dr. Williams received his medical degree from Baylor College of Medicine in Houston, Texas and his Bachelor of Arts & Sciences degree from Howard University in Washington, D.C.

Board certified in Internal Medicine and Cardiovascular Disease

Elie Abed, MD

Dr. Abed is a specialist in endocrinology at Oklahoma Heart Institute. He completed a Fellowship in endocrinology, diabetes and metabolism at the University of Oklahoma Health Sciences Center in Oklahoma City, OK. Dr. Abed performed his Internal Medicine Internship and Residency Programs at Mount Sinai St. Luke's and Mount Sinai West Hospitals in New York, NY. He received his medical degree from Saint Joseph University, Beirut, Lebanon.

Board certified in Internal Medicine

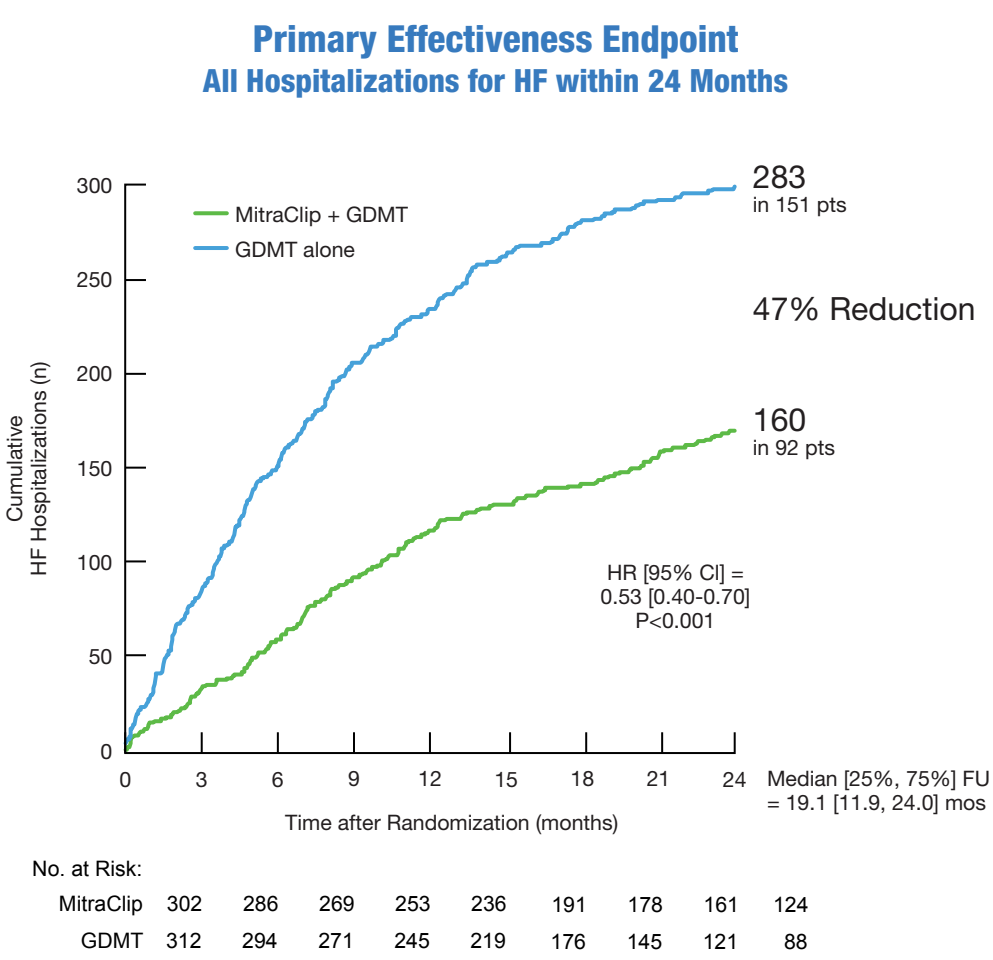
Secondary Mitral Regurgitation:
Summarizing the COAPT Trial

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

The mitral valve is a complex structure involving leaflets, annulus, chordal structures, and papillary muscles. Primary mitral regurgitation (MR) is caused by leaflet abnormalities (myxomatous changes, valvular prolapse, endocarditis damage). Secondary mitral regurgitation (MR) in enlarged ventricles is a cardiovascular disease condition with enormous impact on the general population and contributes greatly to high mortality in patients with heart failure with reduced ejection fraction (HFrEF). Secondary MR (also known as functional MR) occurs when the mitral valve leaflets and chordae are structurally normal and the MR results from alterations of ventricular geometry and function, causing incomplete valve coaptation or distortion of the apparatus. The severity of mitral regurgitation has traditionally been graded as none (0), mild (1+), moderate (2+), moderately severe (3+), and severe (4+). There have been struggles to give a therapeutic answer for this clinical situation. Previous surgical trials using an undersized mitral annuloplasty ring to treat annular dilation (a ventricular problem) and secondary MR have been largely negative. Percutaneous edge-to-edge mitral valve repair (using a MitraClip device) has offered a less invasive way of decreasing the severity of secondary MR when used with guideline-directed medical therapy (GDMT).

The recent MITRA-FR (Percutaneous Repair with the MitraClip Device for Severe Functional/Secondary Mitral Regurgitation) trial utilized percutaneous mitral valve repair to treat patients with HFrEF and secondary MR in addition to medical therapy. The MITRA-HF trial met with neutral results when compared to medical therapy after one year.[1]

The COAPT (Cardiovascular Outcomes Assessment of the MitraClip Percutaneous Therapy for Heart Failure Patients with Functional Mitral Regurgitation) was a multicenter, randomized, controlled, parallel-group, open-label trial of edge-to-edge transcatheter mitral valve repair with the MitraClip device. Those enrolled were symptomatic (New York Heart Association Class I, II, III, or ambulatory IV) patients with heart failure (HF), moderate-to-severe (3+) to severe (4+) mitral regurgitation, symptomatic, on stable maximal GDMT, and cadiac resynchronization therapy (if appropriate). From December 27, 2012 through June 23, 2017, 614 patients at 78 centers in the United States and Canada were enrolled in the trial with 302 randomly assigned to the MitraClip group and 312 to the medical (control) group. The baseline characteristics were well matched for age, gender, medical therapy, and previous resynchronization therapy, and cause of the cardiomyopathy (ischemic versus nonischemic). The mean left ventricular ejection fraction was 31%. The mitral regurgitation grade was 3+ in 52% and 4+ in 48%. Device implantation was attempted in 293 or the 302 patients (97%) in the device group with one or more clips implanted in 287 patients (98%) of the 293 patients where implantation was attempted. A mean of 1.7 clips were implanted per patient, ranging from one to four. Mitral regurgitation severity grade was 1+ or lower in 214 patients (82.3%), 2+ in 33 patients (12.7%), 3+ in nine patients (3.5%), and 4+ in 4 patients (1.5%). Within the MitraClip group, the 30-day rates of death and stroke were 2.3% and 0.7%, respectively, and no patients underwent mitral valve surgery.[2]



The primary effectiveness endpoint of this trial was HF hospitalization within 24 months. The primary safety endpoint was freedom from complication related to the MitraClip at 12 months. The prespecified performance goal had been set at 88%. At one year, the performance goal for the primary safety endpoint was exceeded with a rate of freedom from device-related complications at 96.6%. At two years, the MitraClip gave a 38% reduction in mortality. The composite of death or first HF hospitalization was reduced by 43% in patients assigned to the device.[2]

The mitral regurgitation severity was significantly reduced in the MitraClip group at one year compared with the control group. More patients assigned to the MitraClip group had mitral regurgitation of 2+ or less compared with those assigned to medical therapy alone (94.8% vs. 49.6%). At one year, 72.2% of the MitraClip group had New York Heart Association Class I or II HF symptoms as opposed to 49.6% in the medical therapy group.[2]

The MITRA-HF trial showed no significant difference between the comparison groups (Mi-

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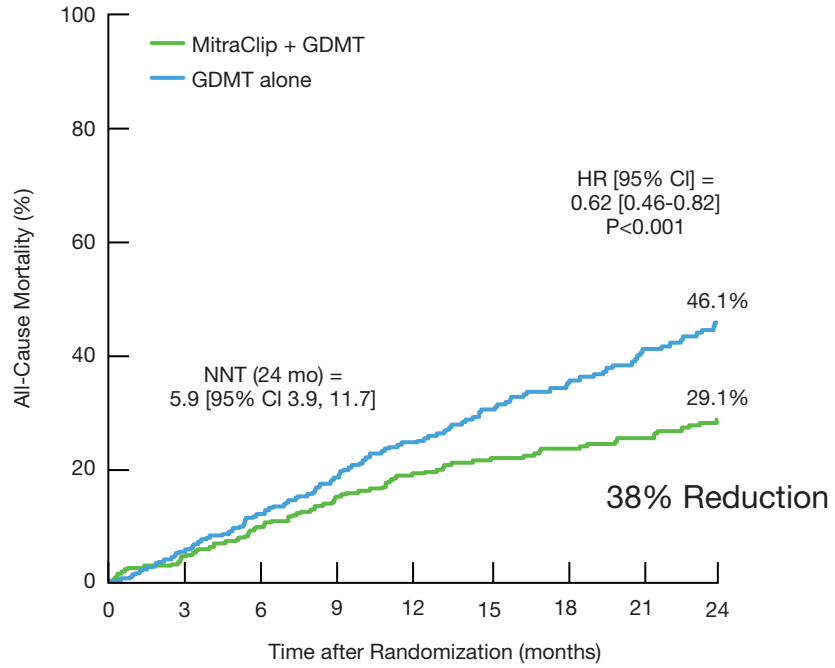
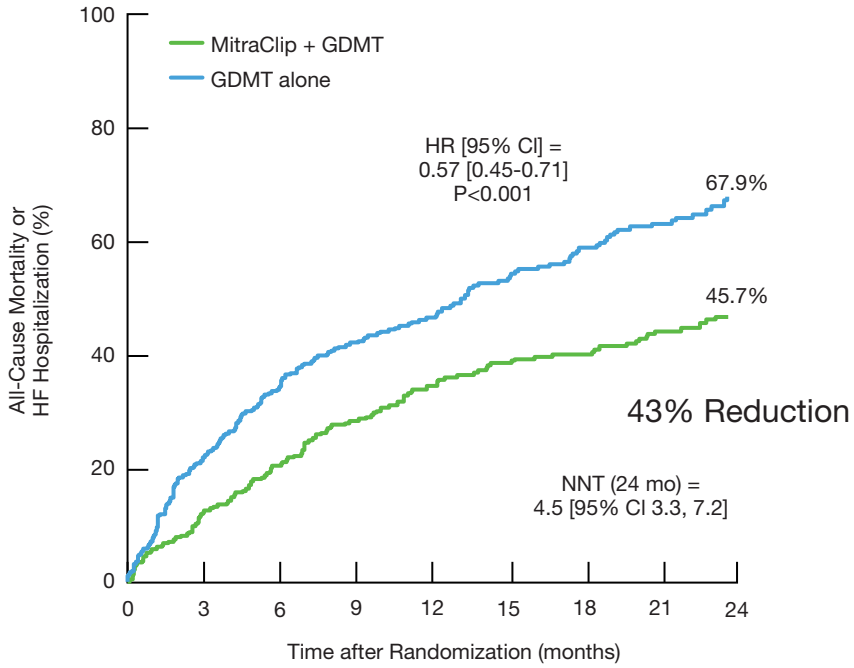
All-Cause Mortality



No. at Risk:

MitraClip + GDMT	302	286	269	253	236	191	178	161	124
GDMT alone	312	294	271	245	219	176	145	121	88

Death or HF Hospitalization



No. at Risk:

MitraClip + GDMT	302	264	238	215	194	154	145	126	97
GDMT alone	312	244	205	174	153	117	90	75	55

Continued from p. 17

traClip vs. medical) with respect to rate of all-cause death or unplanned HF hospitalization at one year. The COAPT trial showed a significantly lower rate of hospitalization for HF at two years (primary outcome) and lower all-cause mortality at two years (secondary outcome) for the MitraClip group. Possible reasons for the different findings are several. The COAPT trial patients were stated to be at maximum tolerated GDMT at the time of randomization to their respective groups. This would allow patients with medically-refractory HF to enter the trial as opposed to the MITRA-HF trial. When comparing the medical arms of the COAPT trial and the MITRA-HF trial, the COAPT trial patients had a higher baseline N-terminal BNP, higher annualized rate of HF hospitalization, lower percentage of New York Heart Association functional class I or II patients at one year, and larger left ventricular end-diastolic volumes at the time of follow-up studies. Another reason may be that the patients in the COAPT trial had more severe mitral regurgitation than those in MITRA-HF (based on a regurgitant orifice of 41 mm2 vs. 31 mm2 at baseline). In spite of the difference in severity of baseline mitral regurgitation between the trials, the patients of the MITRA-HF trial did have larger left ventricular volumes than the COAPT trial, thus attesting to the complexity of the disease state. A third reason may be the procedural performance difference between the two trials, as a greater proportion of patients in the COAPT trial received more than a single clip compared to patients in MITRA-HF. A larger percentage of patients in the MITRA-HF trial had 3+ to 4+ MR at one year than did the COAPT trial, possibly suggesting that the potential benefits of the MitraClip may have been lost.[3]

Treatment of secondary MR remains very difficult. The condition is a disease of the left ventricle and not of the mitral valve. Continued management of left ventricular dysfunction with GDMT should be pursued to maximum efforts and use of resynchronization therapy implemented if appropriate. The COAPT trial has shown that catheter-based edge-to-edge mitral valve repair (MitraClip) may have a role when performed in high-volume centers with high degrees of success and can result in sustained reduction in the severity of secondary MR. Patient selection will continue to play a great role in successfully utilizing this technique. It appears that the device may find success in patients with medically-refractory HF (and resynchronization), moderately severe to severe (3-4+) MR, and less left ventricular dilation (than those patients in the MITRA-HF trial).

Overall, the MitraClip is the first therapy shown to improve the prognosis of patients with heart failure by reducing secondary mitral regurgitation due to left ventricular dysfunction.

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.

References:

1. Obadia, J-F, et al. Percutaneous repair or medical treatment for secondary mitral regurgitation. N Engl J Med 2018; 379: 2297-2306.
2. Stone, GW, et al. Transcatheter mitral-valve repair in patients with heart failure. N Engl J Med 2018; 379: 2307-2318.
3. Nishimura, RA, et al. Percutaneous repair of secondary mitral regurgitation – a tale of two trials. N Engl J Med 2018; 379: 2374-2376.

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teries revealed only mild peripheral artery disease. Angiography of the left popliteal artery revealed a chronic total occlusion in the proximal segment with reconstitution via collateral flow in the distal segment of the popliteal artery (figure 9a). Because of the patient's advanced age and severe chronic lung disease she was deemed to be a poor candidate for surgical revascularization. Therefore attempts were undertaken to treat the chronic total occlusion with endovascular techniques. A Glide Advantage wire was advanced across the length of the chronic total occlusion through a Trailblazer support catheter. Although fluoroscopic imaging initially suggested the system was in the true lumen of the vessel (figure 9b), because of inability to aspirate blood through a support catheter, an oblique angiogram was performed that revealed the system had entered the subintimal space adjacent to the true lumen of the vessel (figure 9c). Therefore, an Outback reentry device was used to direct a Hydro-ST guidewire back into the distal true lumen of the vessel (figure 9d). Angioplasty and stenting were performed without difficulty and an excellent angiographic result was achieved (figure 9e). The patient experienced resolution of her ischemic rest pain. This case illustrates the need for endovascular specialists to sometimes push beyond the classic boundaries of endovascular treatment in patients who might be poor surgical candidates as successful completion of this case required the unorthodox use of a reentry device and stent placement in the popliteal artery. It should be noted that this patient died approximately four years after this procedure was performed due to progression of her lung disease, but annual surveillance duplex studies confirmed patency of the popliteal artery stent during those remaining four years of her life.

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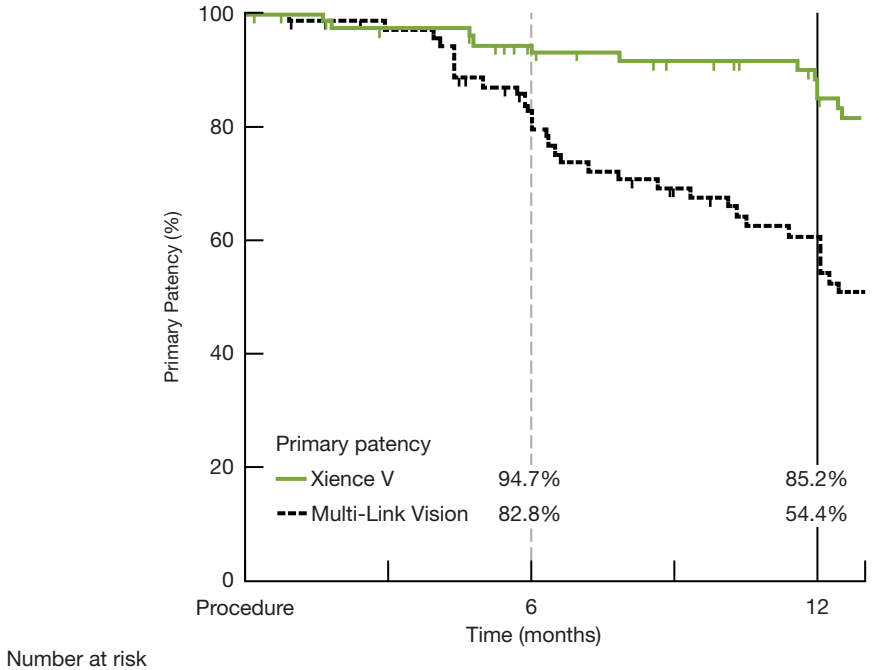
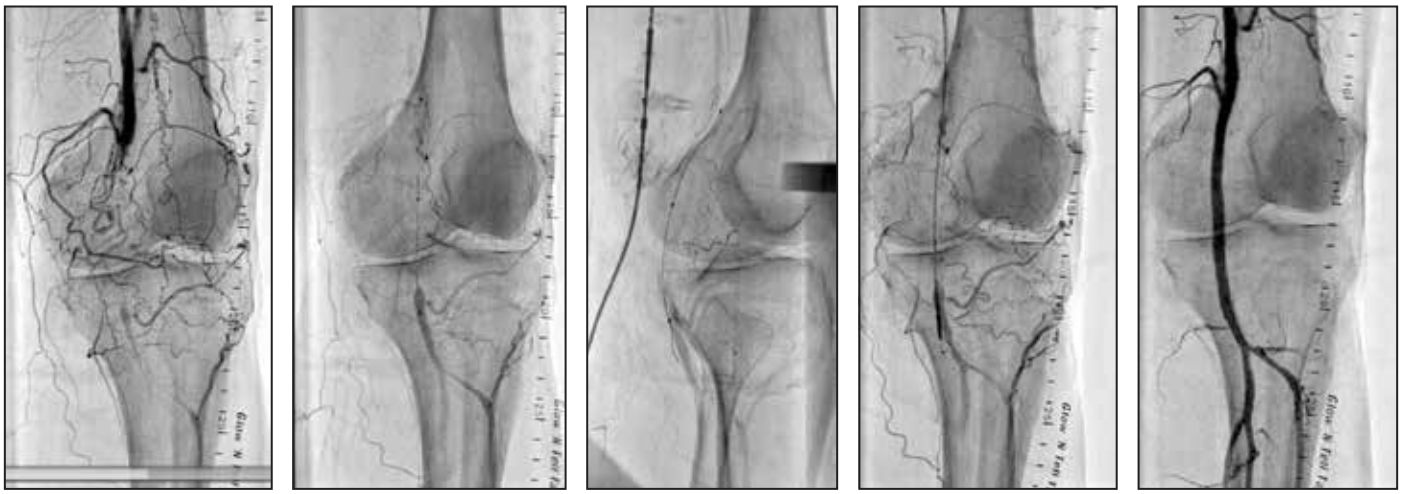
Figure 8

Results of the DESTINY trial that demonstrated the long-term benefits of using coronary drug eluting stents to treat infrapopliteal disease



J Vasc Surgery 2012; 55: 390-0

Figure 9



(A) Angiography of the left popliteal artery reveals a chronic total occlusion in the proximal segment with reconstitution via collateral flow in the distal segment of the popliteal artery.

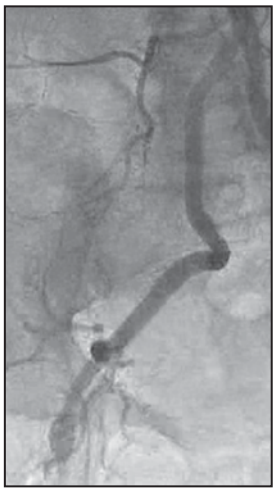
(B) Angiography initially suggested the system was in the true lumen of the vessel after crossing the length of the occlusion.

(C) Oblique angiogram reveals the system actually entered the subintimal space adjacent to the true lumen of the vessel.

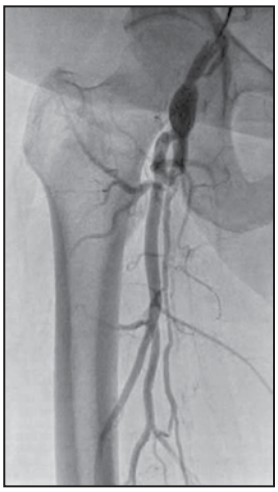
(D) Outback reentry device used to direct a Hydro-ST guidewire back into the distal true lumen of the vessel.

(E) Excellent final result after angioplasty and stent placement.

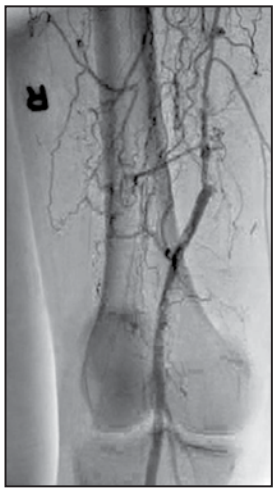
Figure 10



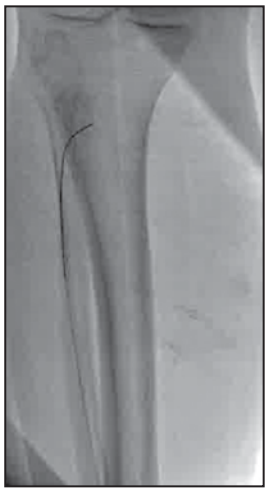
(A) Baseline angiography reveals a patent but extremely tortuous right ileo-femoral conduit.



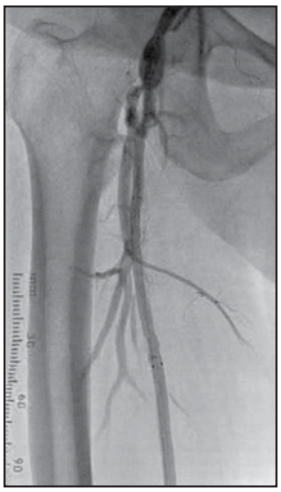
(B) Baseline angiography reveals a chronically occluded right femoral to popliteal artery bypass graft, and a chronically occluded right superficial femoral artery.



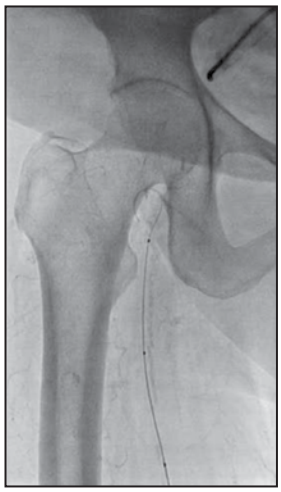
(C) Baseline angiography reveals reconsititution of flow in the distal segment of the right superficial femoral artery via an arcade of collateral flow.

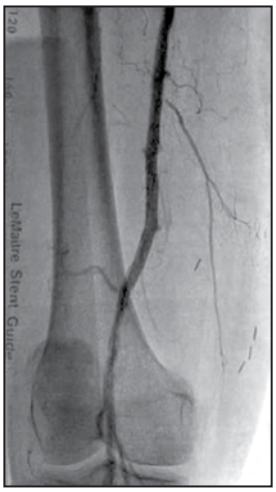


(D) Angiogram demonstrating a wire advanced retrograde up the anterior tibial artery via a dorsal pedal artery access site.



(E) Angiogram demonstrates a Glide Advantage wire and a Trailblazer support catheter that were advanced retrograde across the entire length of the superficial femoral artery chronic total occlusion to the level of the right common femoral artery.





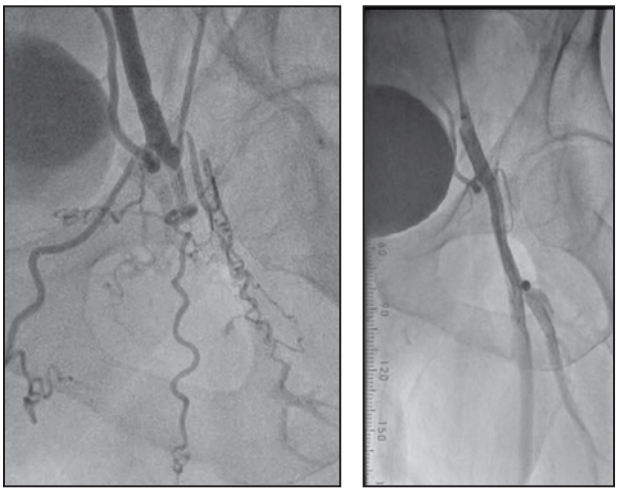
(F-G) Final angiogram reveals an excellent result after angioplasty and stent placements across the right superficial femoral artery chronic total occlusion.

Continued from p. 19

CASE 4

A 59-year-old woman presented reporting many years of ischemic rest pain in her right lower extremity. The patient had a very complex history of cardiovascular disease that included remote coronary artery bypass graft surgery with only one known remaining bypass conduit, prior right iliac artery reconstruction, and right femoral to popliteal artery bypass graft surgery. Angiography in the right lower extremity was remarkable for a patent, but extremely tortuous right ileo-femoral conduit (figure 10a), a chronically occluded right femoral to popliteal artery bypass graft, and a chronically occluded right superficial femoral artery with reconsititution of flow in the distal segment of the right superficial femoral artery via an arcade of collateral flow (figures 10b-c). Because the patient was deemed high risk for surgical revascularization due to severe residual coronary disease, and because the patient adamantly refused to undergo another lower extremity bypass operation, she was offered an attempt at endovascular intervention. Because of the severely tortuous right ileo-femoral conduit and ambiguous proximal cap anatomy, we elected to approach the chronic total occlusion retrograde via a pedal access site. Using ultrasound guidance, the dorsal pedal artery was accessed retrograde via a 5/6 French slender sheath, which allowed a wire to be advanced up the dorsal pedal artery (see figure 10d). Ultimately, a Glide Advantage wire and a Trailblazer support catheter were advanced across the entire length of the superficial femoral artery chronic total occlusion to the level of the right common femoral artery where it spontaneously entered the true lumen of the vessel (figure 10e). Angioplasty and stenting were performed via retrograde delivery. Final angiograms revealed an excellent result (figure 10f-g). The patient's symptoms improved dramatically. This case illustrates the need for endovascular specialists to possess the skills to obtain pedal artery access in order to overcome complex anatomical obstacles that cannot be solved using standard antegrade techniques.

Figure 11

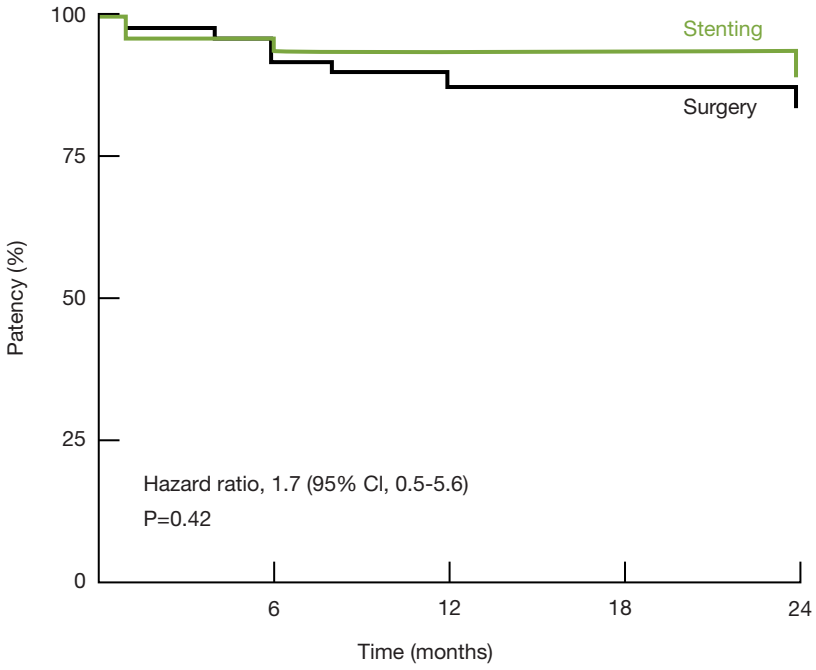


(A) Angiography demonstrates a chronic total occlusion of the left common femoral artery.

(B) Final angiogram reveals an excellent result after angioplasty and stent placement.

Figure 12

Recently published randomized data suggest that stenting in the common femoral artery provides durability that is at least as good as surgery



J Am Coll Cardiol Intv. 2017: 10: 1344-1354

CASE 5

An 81-year-old gentleman with mild dementia who had been experiencing chronic pain in his left leg for many years mistakenly attributed to osteoarthritis, was referred after he developed a poorly healing ulceration on his left anterior shin. Angiography was remarkable for a chronic total occlusion of the left common femoral artery with reconstitution at the level of the femoral bifurcation via collateral flow (figure 11a). Because of the patient's advanced age and mild dementia, an endovascular approach was preferred. A Glide Advantage wire and Trailblazer support catheter were carefully advanced across the length of the chronic total occlusion. Because of concerns about the risk of distal emboli, the Glide Advantage wire was exchanged for a Spider distal embolic protection device. After performing angioplasty and stenting in the common femoral artery, an excellent angiographic result was achieved (figure 11b). The patient's wound healed well and his chronic left leg pain resolved. During the following four years, annual surveillance duplex imaging confirmed stent patency in the common femoral artery. Unfortunately, the patient's dementia ultimately progressed to such severity that further surveillance imaging no longer seemed appropriate and the patient was lost to follow up shortly thereafter. This case again highlights the need for endovascular specialists to sometimes push beyond the conventional boundaries of endovascular treatment when caring for patients with critical limb ischemia. When this case was performed, the common femoral artery was still dogmatically described as a "no stent zone" by most vascular specialists. Nevertheless, our patient clearly benefitted from the treatment. Interestingly, recently published randomized data suggest that stenting in the common femoral artery provides durability that is at least as good as surgery (figure 12), and that surgical revascularization of the common femoral artery has significantly more periprocedural morbidity when compared to common femoral artery stenting (figure 13).[8]

CASE 6

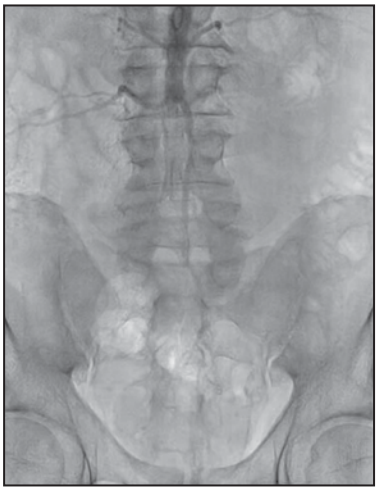
A 52-yearold gentleman presented for a second opinion regarding the management of his recently diagnosed lower extremity peripheral artery disease. The patient described ischemic rest pain in both of his legs that began about six months earlier. He was diagnosed with an occlusion of his distal abdominal aorta several months earlier at an outside facility and originally referred to a surgeon to consider aortobifemoral bypass graft surgery. Apparently, the patient had a family member who had died during a major vascular surgery about 10 years earlier. Due to fears and anxiety regarding potential complications with surgical revascularization, the patient refused bypass surgery. Ultimately, we agreed to offer the patient an attempt at endovascular revascularization. After obtaining right radial artery access, a pigtail catheter was placed in the infrarenal abdominal aorta to perform abdominal aortography. The angiogram confirmed chronic occlusion of the distal abdominal aorta extending into the bilateral common iliac arteries (figure 15a). After obtaining ultrasound guided access of the bilateral common femoral arteries, we were able to carefully cross both the right and left common iliac artery occlusions into the true lumen of the abdominal aorta above the level of the chronic occlusion. Bilateral kissing balloon angioplasty was performed before and after stent deployments (figure 15b). Final angiogram confirmed excellent endovascular reconstruction of the chronic total occlusion (figure 15c). The patient reported complete resolution of his symptoms at follow up. This case again illustrates the need for endovascular specialists to have the skills to overcome complex anatomic obstacles such as chronic total occlusions at all levels of the arterial tree, including the abdominal aorta.

ADDRESSING CARDIOVASCULAR RISK IN CLI PATIENTS

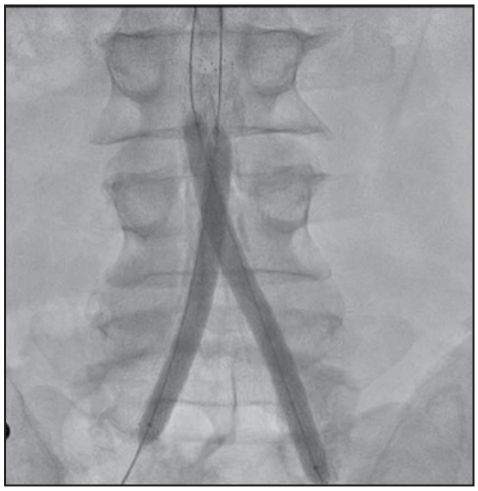
In addition to possessing the highest degree of technical skills demonstrated above, endovascular specialists caring for patients with CLI must also be mindful of the high risk of cardiovascular morbidity and mortality that is present in these patients. In general, patients with peripheral artery disease have an increased risk of death related to myocardial infarction and/or stroke that occurs in 30-50% of patients in the following five years.[9] Patients presenting with critical limb ischemia face that same level of risk in the following one year.[9] Therefore, a helpful guide for physicians caring for patients with peripheral artery disease is provided with the PAD Treatment Triangle (figure 16). The obvious foundation of care for these patients involves the two points at the base of the triangle. For patients with claudication, the goal of therapy is to relieve patients of their symptoms with exercise rehabilitation, pharmacologic treatment such as cilostazol, and/or revascularization. For patients with CLI, the goal of therapy is to protect the patient's feet with aggressive wound care and revascularization (preferably with an endovascular approach). Demonstrated at the top of the PAD Treatment Triangle is the need to prevent cardiovascular morbidity and

(continued on p. 22)

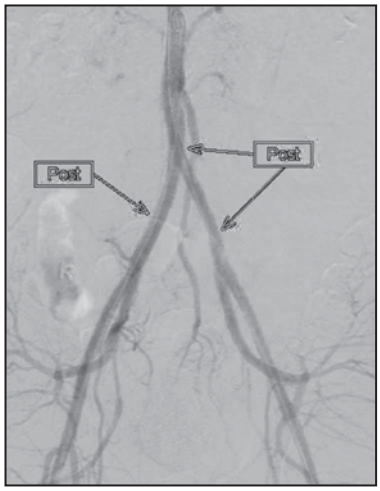
Figure 15



(A) Baseline angiogram documents chronic occlusion of the distal abdominal aorta.



(B) Bilateral kissing balloon angioplasty performed before and after stent deployments.



(C) Final angiogram confirms excellent endovascular reconstruction of the distal abdominal aorta chronic total occlusion.

Continued from p. 21

mortality because keeping these patients alive should always be the priority of the physicians caring for these patients. Although a complete discussion regarding the scientific evidence supporting the suggested strategies to prevent cardiovascular morbidity and mortality is beyond the scope of this article, the following approaches are recommended in all patients with peripheral artery disease:

- Smoking cessation
- Antiplatelet therapy (ASA or clopidogrel)
- Cholesterol control with statins (target LDL < 70)
- Hypertension control (ACE inhibitors are preferred)
- Diabetes control (target Hgb A1C < 7.0)
- Therapeutic lifestyle changes (heart healthy diet, routine exercise)
- Annual flu shot

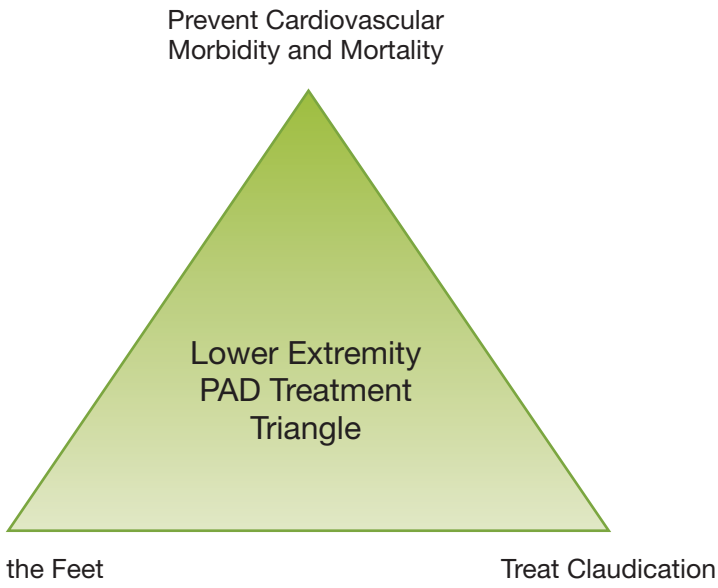
Additionally, patients with peripheral artery disease should be directly educated and questioned regarding any potential anginal symptoms and/or stroke symptoms at every follow up opportunity. Providers should maintain a low threshold for pursuing further evaluation of the coronary and/or carotid vasculature if any potential symptoms are reported.

CONCLUSIONS

Critical limb ischemia is a complex medical problem that requires an aggressive multidisciplinary approach to treatment. Patients presenting with CLI have a high risk for major amputation within 1 year without revascularization. Despite the high risk for amputation, many patients in the United States undergo amputation without ever having undergone angiography to determine if they might be a candidate for revascularization. Recently published algorithms suggest anatomically defining the extent of peripheral artery disease in all patients with poorly healing wounds or ischemic rest pain. Normal ankle-brachial indices should not be used to rule out peripheral artery disease in these high risk patients. After defining the extent of peripheral artery disease in CLI patients, revascularization should be pursued, preferably with endovascular techniques, when possible. Providers should also be mindful of the high risk for cardiovascular morbidity and mortality that is present in CLI patients; strategies should be integrated into the care of CLI patients to reduce their high risk for myocardial infarction, stroke, and death.

Figure 16

Peripheral Artery Disease Treatment Triangle



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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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