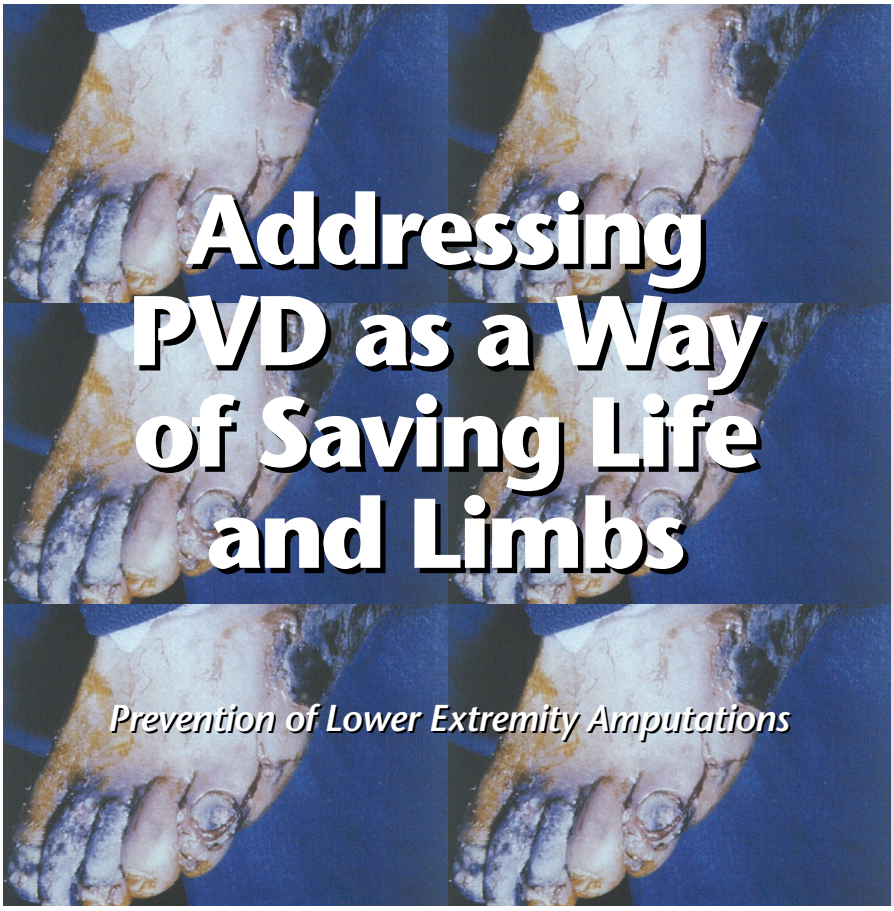
Continuing Medical Education



Addressing PVD as a Way of Saving Life and Limbs

Prevention of Lower Extremity Amputations

Objectives

After reading this continuing education article, the podiatric physician should be able to do the following:

1) Recognize the signs and symptoms of critical ischemia.

2) Identify the common causes of chronic and progressive atherosclerotic disease of the lower extremity.

3) Differentiate between vascular disease and those conditions that mimic vascular disease.

4) Appreciate the significance of peripheral vascular disease as it relates to mortality and morbidity.

5) Understand the importance of a global team approach to limb salvage and the ability to interact with, and have access to, the critical members of that team.

6) Identify where peripheral arterial blockages occur in the lower extremities.

7) Discuss the medical, interventional and surgical treatment options involved in limb salvage.

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*Following this article, an answer sheet and full set of instructions are provided (p. 136).—**Editor***

By Kenneth B. Rehm, D.P.M.

The podiatric physician has the opportunity to be one of the most instrumental healthcare practitioners in the prevention of the loss of the lower limbs. D.P.M.'s probably are exposed to as many patients at risk for losing their limbs as any other medical specialty. Most commonly, prevention of amputation is associated with identifying risk factors associated with diabetes mellitus such as neuropathic loss of protective sensation and peripheral vascular disease. This is important in that identifying risk factors can be preventive; but trauma, ulcerations and infections still occur. Once these occur, healing is challenged by lower extremity arterial occlusive disease, which is directly responsible for loss of limb, and the

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Photo courtesy of David E. Allie, M.D., Cardiovascular Institute of the South, Lafayette, Louisiana

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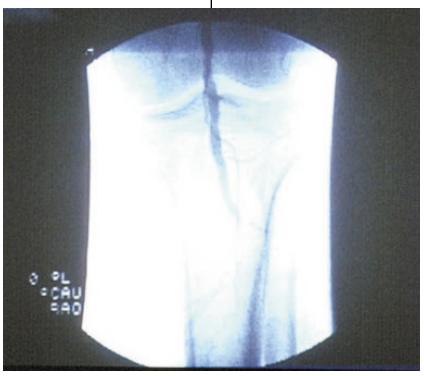
limb salvage process must identify this.

In the foot that is at-risk for amputation, prevention of abnormal pressures during gait through foot orthoses and proper shoes, identifying loss of protective sensation and peripheral vascular disease, protection of the foot from pressure in bed or in wheelchairs, other trauma, proper nail care, prevention of infection and ulceration are critical elements in lower extremity amputation prevention. This is especially true when it concerns the diabetic foot. The ability to improve blood flow, however, to affect healing in the dysvascular foot, to save the limb and to prevent amputation is the subject being addressed here.



Diabetic Pattern of Disease

Recognizing peripheral vascular disease severe enough to prevent healing is another critical element in this process of limb salvage. Signs and symptoms that should be part of the history and physical exam and review of systems should include: the presence and severity of intermittent claudication and the symptoms of critical ischemia of the lower limbs. These are always associated with very severe atherosclerotic disease that is commonly present in multiple areas of the arterial tree from the aorto-ileac junction to the pedal arteries.

Critical ischemia usually presents with the patient having pain at rest. Rest pain usually occurs at night when the person lies supine. This happens because gravity is not assisting in the blood flow to the feet. There is a dull aching sensation in the toes or forefoot. Pain is then relieved when the legs are lowered to the floor. Rest pain foreshadows a dismal outcome if some intervention is not performed.

Ulceration

Often critical ischemia leads to ischemic ulceration. These ulcerations are usually precipitated by an element of trauma, unless an acute thrombus forms. Ischemic limbs have to be protected from even the smallest amount of trauma. When these ischemic ulcerations do not heal, they are likely to form gangrene, another factor of critical ischemia. Ischemic nerves and muscles lead to ischemic neuropathy and muscle mass atrophy and weakness of the lower extremity.

In addition, the review of systems has to include neurologic symptoms, abdominal pain, hypertension and signs of renal insufficiency to adequately ascertain clinically significant peripheral vascular disease. The podiatrist has an opportunity to provide important preventive information if he or she is very astute in the examination of a patient that presents with suspected peripheral vascular disease. PVD is detectable in routine practice, so podiatrists can be an instrumental part of a team that improves the lifestyle of persons affected, thereby preventing amputations that occur secondary to lack of blood supply needed to heal wounds and infections.

The Ankle Brachial Index

Checking blood pressures in the upper and lower extremities and getting an ankle-brachial index (ABI) on patients suspected of peripheral vascular disease, even if the patient is asymptomatic, should be a routine procedure in any practice and serves as a valuable predictor of vascular complications.

The Partners study (PAD Awareness, Risk, and Treatment: New Resources for Survival) presented at the year 2000 American Heart Association meeting in New Orleans brought to light several interesting facts.

- The lower the ABI, the higher the risk for symptomatic peripheral vascular disease and even mortality. Even in patients who have no symptoms and who feel great, who have an ABI just barely less than normal, their 10-year mortality rate is 3 times as high as normal patients, implying that future risk of amputation from a wound or infection is also higher.
- 40% of patients with peripheral vascular disease and no symptoms have coronary artery disease.
- 80% of patients with symptomatic vascular disease have coronary artery disease. Risk factors of PVD include age over 70, younger individuals (from 50-69) who smoke and/or have diabetes, gender, lipids, hyper-

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tension, post-menopausal status.

A patient with compromised circulation that is at risk for losing all or part of their lower extremity could have sustained an acute injury, embolus or thrombosis. However, more commonly podiatrists deal with lower extremity arterial occlusive disease that occurs because of chronic and progressive atherosclerotic disease that occurs commonly because of diabetes, hypertension, hypercholerolemia, cardiac disease, hyperlipidemia and tobacco use.

The lower the ABI, the higher the risk for symptomatic peripheral vascular disease and even mortality.

Other Mimicking Diseases

Conditions that mimic vascular disease such as pseudoclaudication, cauda equina syndrome, or neurologic diseases must be ruled out. Patients who have these non-vascular conditions can get some degree of symptomatology without any effort, activity, lower extremity elevation or dependency. Also, sitting down often provides relief. These are key differentiating markers.

Controlling blood sugars, hypertension, cholesterol, and tobacco use can have a very significant positive impact on peripheral vascular disease and the success of any vascular intervention. Diabetes increases the severity of peripheral vascular disease when combined with other causative factors, therefore making it crucial to control a patient's diabetes especially when there are other co-morbidities involved.

PVD is a marker of death and is widely undiagnosed. The life expectancy is reduced by 10 years in patients with PVD. The mortality rate once PVD is diagnosed is 25% at 5 years, 50% at 10 years and 75% at 15 years. The mortality rates of those with PVD are 3 times higher than those without. (J. Cardiovascular Surg 1989; 30: 30-57) and is higher than those suffering from Hodgkin's disease and breast cancer. The chance of dying from an acute coronary occlusion is about the same as from occlusive disease of the lower extremities. Limb ischemia can be a marker for carotid as well as renal artery disease.

The patient with PVD should be treated with a global team approach. Critical members of the team include the vascular surgeon, the plastic surgeon, the angiographer or interventional radiologist, the podiatrist, the primary care physician and diabetologist, the neurologist, the cardiologist and wound care nursing staff. The earlier the diagnosis and treatment the more successful this team can be at limb salvage. Lack of diagnosis and global treatment allows PVD patients to remain at elevated risk for heart disease, stroke, and amputation.

The presence of PVD is increasing, especially in the aging society. The prevalence of severe symptomatic PVD increases with age: 3% of the population from 40-59 years of age, 8% from 60-69, and 19% of the population over age 70 has severe symptomatic PVD.

Fewer than half of all individuals with PVD are aware that they have it. Even more significant is that physicians are unaware of the presence of PVD in over 70% of their patients. Diabetics and smokers are at the highest risk of PVD, 50% of diabetics will develop a blockage in their legs after having the disease ten years or more. Atherosclerosis of the peripheral arteries is the most common cause of symptomatic obstruction in the peripheral arterial tree.

Completion arteriography of femoral-distal pedis in situ bypass

Photo courtesy of David E. Allie, M.D., Cardiovascular Institute of the South, Lafayette, Louisiana

When a patient is seen with severe peripheral vascular disease, several questions have to be answered:

1. What is the vascular diagnosis or the cause of the vascular compromise?

2. Is the problem severe and lifestyle adverse enough to warrant some form of direct therapy?

3. Where is the anatomic location of the disease?

4. Is surgical or non-surgical treatment indicated?

A comprehensive arteriographic study that encompasses the entire vascular tree from the level of the ab-

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dominal aorta into the foot usually provides the answers to these questions. Before any surgical, endovascular or interventional procedure is performed, the physician needs to know where the pathology is and whether the inflow to a reconstruction is adequate and whether the outflow vessels from the repaired area can handle a new volume of blood. In addition, vascular disease proximal to the inguinal ligament as well as cardiac disease must be evaluated.

Where do we develop peripheral arterial blockages affecting the legs?

Lower extremity arterial occlusive disease usually occurs in one or more of three areas: aortoiliac, femoropopliteal, and below the knee. Specifically, the most common places for peripheral arterial diseases to occur are:

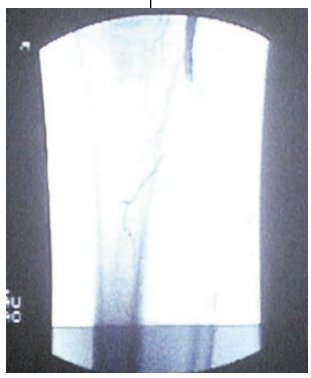
1. The origin of the common iliac arteries or aortic bifurcation.

2. The common femoral artery, which is most commonly due to trauma or injury after prior angiography.

3. The superficial femoral artery at the adductor or Hunter's canal where the adductus magnus muscles, which pull our legs toward the midline, chronically traumatize the artery. This is the most diseased artery in the body and the most common site for atherosclerotic diseases. The second most common place is at the origin of the superficial femoral artery.

4. Infrapopliteal area, which is very common in diabetic patients, but not uncommon in non-diabetics.

The disease may be confined to any one of these areas; however, a growing number of patients are presenting with multi-segmental involvement. These patients usually present with critical ischemia. Depending on the severity and the location of the disease, the sophistication of newer diagnostic surgical and non-surgical treatment options are allowing an increasing number of lower limbs to be saved. In addition, every patient with ischemic ulceration or early gangrene is entitled to an angiogram to assess recoverability of tissue loss and reduction in the level of amputation, before amputation is considered.



Occlusion of the Infra-Popliteal Vessels

Photo courtesy of David E. Allie, M.D., Cardiovascular Institute of the South, Lafayette, Louisiana

Traditionally, the investigation of patients with suspected or known arterial disease requires both physiologic and anatomic documentation. The physiologic data indicate the extent to which the arterial disease has interfered with perfusion, and anatomic information is needed to assess what treatments are needed.

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Standard of Care

The standard of care in patients with significant vascular compromise is to perform the appropriate angiography before any surgical, endovascular or interventional procedures are performed. Good intervention or surgery starts with good angiography. A single bolus injection angiogram in which we may or may not see the appropriate pathology is not the best program for visualizing diseased vessels in the foot because in severe disease, the dye commonly takes a longer period of time than what is usually standard, to reach the foot. A collateral vessel may be supplying the foot and would never be seen. Another consideration important in visualizing arterial disease is to be sure that oblique views are taken. These will show disease hidden by overlapping vessels, so if there is suspicion of disease, it is essential that oblique views be taken.

Treatment Options

Once the diagnosis is made either through invasive or non-invasive methods, there are ever-expanding therapeutic options that might be available to the patient depending on the pathology involved.

Previously, there was just surgery or medications. Now there are newer medical, surgical, endovascular and interventional techniques as well as physical therapeutic modalities, available now that were not available 10 years ago. These can be especially effective when used in combination to compliment each other. We can now save limbs that never had a chance 10 years ago.

Risk Factor Modification

Medical therapy involves risk factor modification. The medical establishment and the patient population have become more aware of risk factors as well as being more willing and motivated to deal with risk factor modification, which in a large sense deals with lifestyle, diet, exercise, quitting smoking and good preventive medical care.

Improving lifestyle involves analyzing and minimizing lifestyle-limiting factors such as one's vocation, avocations, social and psychological factors, personal expectations and dealing in a positive way with medical problems and limitations. Improving exercise alone can accomplish significant improvement in patients with claudication. A supervised exercise program improves walking distance by 3 blocks within 6 months of training according to a meta analysis of 21 studies reported by Emile Mohler III, M.D at the Cardiovascular Horizons Conference of 2000.

Control of the contributing diseases, such as obesity, hypercholesterolemia, hypertension, diabetes and hyperlipidemia through lifestyle, diet, exercise and medications is the cornerstone of good medical management of peripheral vascular disease, according to many experts.

Controlling cholesterol can be accomplished using a statin drug (Simvastatin, aka Zocor® or other cholesterol-lowering drugs. In one angiographic study (Blankenhorn and colleagues in 1970), patients on cholesterol-lowering drugs actually impeded the progression of disease in the femoral artery. Niacin has been effectively used as part of a combination program of cholesterol control.

PVD Medications

The medications used to treat PVD, either as a sole treatment or as an adjunct to other therapies, fall into three categories:

1. Those that have vasodilating activity such as the ACE inhibitors. These medications block the ACE enzyme in the kidney, causing peripheral vasodilatation and decreased blood pressure. An example of an ACE inhibitor is Ramipril.

2. Those that have thrombolytic activity, such as Retavase, Activase, Reopro, and TPA (Alteplase)

3. Those that have anti-platelet activity such as Pletal (cilostazol), Aspirin, Persantine (dipyridamole), and ADP receptor antagonists Ticlid (ticlopidine) and Plavix (clopidogrel). The goal with these medications is to decrease fibrinogen linking of the platelets and therefore decrease platelet aggregation and diminish its negative effects.

Anti-Platelet Therapy

Anti-platelet therapy is becoming universally important in the treatment and prevention of atherosclerotic buildup in the artery. Only about a third of patients, according to the "Partner Study", that should be treated with anti-platelet therapy are being treated.

The patient with PVD can have silent occlusion, usually of the superficial femoral artery because of atherosclerotic plaque rupture in the periphery and thrombus forma-

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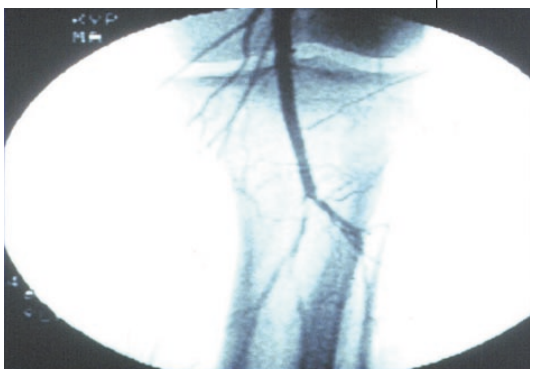
tion. Loss of blood flow to the limbs can occur without symptomatology because of collateral circulation that develops within the profundus artery. This collateral system usually does not form atherosclerosis. In addition, it is thought that skeletal muscle, which is fed by the femoral artery and its collaterals, is relatively resistant to ischemia. This commonly decreases distal blood flow. Because of this scenario of plaque rupture, thrombus formation, and decreased blood flow to the lower extremity, anti-platelet therapy is indicated in patients with PVD.

The data indicates that all patients with PVD should be on anti-platelet therapy unless otherwise contraindicated.

Pletal (cilostazol) has been shown to be multi-dimensional in activity. It is effective in 1) the inhibition of platelet activity, 2) inhibition of thrombosis, 3) inhibition of smooth muscle cell proliferation, 4) increasing limb blood flow, 5) improving lipid metabolism 6) vasodilatation and is being used more commonly in patients with peripheral vascular disease and very successfully to decrease intermittent claudication.

More studies are being done for newer medications involving prostaglandins, newer anti-platelet medications, L-Arginine and other factors that improve the formation of nitric oxide (which is a vasodilator and anti-platelet agent), angiogenic factors, growth factors and gene therapy to improve peripheral vascular disease.



Total Occlusion of the Trifurcation

Photo courtesy of David E. Allie, M.D., Cardiovascular Institute of the South, Lafayette, Louisiana

Controlling Diabetes

Controlling diabetes is important and effective. Diabetes accelerates atherosclerosis by 200%-400% and PVD is 11 times more prevalent in the diabetic population than in the general population. Rigid control of blood sugars can decrease the severity of complications that occur and decrease the accelerated atherosclerotic process. Using the HbA1C as a guide, blood sugar levels can be monitored and controlled. Using the various hypoglycemic agents that work best for the individual can modify the lipid profile. If limb salvage is to be effective, we must take an aggressive approach to the diabetic foot.

Amputations

The most common cause of hospitalization in the diabetic population is diabetic foot problems, which result in an annual cost of over 1 billion dollars. One half of the

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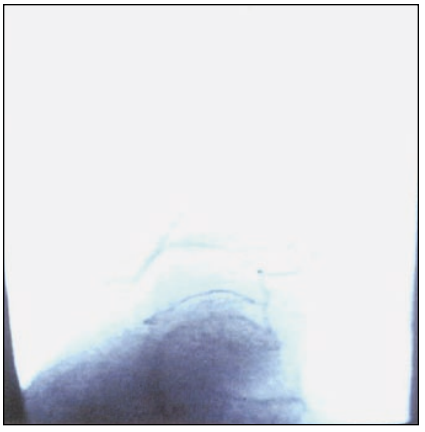
amputations performed in the United States today are done on diabetic patients. The risk of amputation is 40 times greater in a diabetic than in the general population. 15% of all diabetics will experience a foot ulceration in their lifetime, and a high percentage of these will result in amputation due to inability to heal the wound. There are as many as 200,000 amputations in these patients in a single year in the United States.

Amputations are not benign events. Psychological testing after amputation shows that amputees may lose their spirit for the rest of their lives. They score a more negative psychological profile than even cancer patients do. Also there is a 10%-20% 30-day peri-operative mortality rate with a below-the-knee amputation and a 20%-40% with an above-the-knee amputation, in part due to sepsis and myoglobinurea.

Patients commonly do not do well after amputation. Full mobility is accomplished in only 50% of patients after a BKA and in only 25% of patients who have undergone an AKA. Up to 50% of all patients who have had an amputation will die within 2 years of the surgery. These numbers reflect the necessity for considering limb salvage a priority.

Small vessel disease is a misconception (J. Vasc. Surg. 1999; 30373-94) and dispelling this false notion is fundamental to the principles of limb salvage in diabetics as arterial revascularization is almost always possible in these patients. The diabetic has a specific atherosclerotic pattern. The superficial femoral artery and the popliteal artery are often spared. The infragenicular vessels at the trifurcation (posterior tibial, peroneal, and anterior tibial) are often occluded until they reach the foot, at which time these vessels (the dorsalis pedis and posterior tibial artery) are often spared. This is called "pedal sparing." If we don't take this into consideration, we are not giving the patient an opportunity for a revascularization procedure, as this is unfortunately commonly the case.



Sparing of the Pedal Vessels

Sparing of the Pedal Branches

Another misconception in diabetic patients is that they have untreatable occlusive lesions in the microcirculation. (J. Vasc. Surg. 1999; 30: 373-84). The capillaries do not have significant abnormalities. The histologic pattern of disease at the pedal and pedal capillary levels in diabetics and non-diabetics are similar. The pathologic lesions are in the endothelium of the larger vessels. These patients must have a special type of angiography. We must have complete pedal angiography.

Occlusive Angiography

One technique that is not considered standard is called balloon occlusive angiography, where the catheter is taken as distally as possible, a balloon is inflated, and dye is injected distal to the balloon. This is absolutely necessary to visualize the vessels of the foot and prevent amputation. There is also a technique called digital subtraction angiography, which is a technique that helps highlight the pathology in the foot. Once patent pedal vessels are identified, various surgical procedures can be performed.

One procedure is a dorsalis pedis arterial bypass. This is best done using an autogenous vein. This surgery requires a patent distal anterior tibial and the terminal branch of the dorsalis pedis artery, which will accept a bypass. This is very meticulous surgery as the bypass vessels could be as small as 1.5 to 2 mm, the size of coronary vessels. If an autogenous vein is a problem, and there is a patent SFA, a shorter bypass graft can be utilized, going from the midthigh to the pedal vessels with inflow from the popliteal artery.

If patients do not have an adequate autogenous greater saphenous vein, there are other conduits available. Options include:

- Use of the lesser saphenous vein visualized through pre-operative vein Doppler mapping
- Popliteal bypass surgery approach from the back of the leg, allowing the use of less of a vein.
- Using cryopreserved veins harvested from accident victims or cardiac or kidney donors.
- Blind exploration surgery.
- The use of arm veins.

Sometimes composite grafts, that is, connecting a vein to a vein or a vein to a Gore-Tex graft, have been used successfully. Indications for vascular bypass surgeries include claudication, rest pain, failed previous graft, gangrene, and non-healing arterial ulcers of the lower extremity. Other common areas of bypass include infrainguinal bypass, below the knee bypass, and infrapopliteal bypass. One has to differentiate between patency rates and salvage rates. The patency rates published might be poor, but even though a graft may close off after a few years, the graft may last long enough for the patient's limb to be permanently salvaged. One has to be aware that before these bypass surgeries are performed, most of these would have faced certain amputations and had no other options.

With this in mind, we must be aggressive in avoiding amputations. This requires awareness that diabetic foot problems and amputation are associated with significant morbidity and mortality. After an amputation, there is a 50% 2-year mortality. Misconceptions regarding diabetes-related small vessel disease must be dispelled. Practitioners must be aware of "pedal sparing" and must perform limb salvage angiography using special techniques for the di-

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Photos courtesy of David E. Allie, M.D., Cardiovascular Institute of the South, Lafayette, Louisiana

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abetic foot. There are distal surgical targets, even though sometimes they are not evident, and diabetics can have limb salvage. The distal pedal bypass to the foot is a viable surgical option.

An 8-year study published in 1996 from Boston Deaconess Hospital system involved 385 patients who were sent there from other institutions for amputation after angiograms indicated amputation. The patients underwent repeat angiography using the specialized techniques mentioned. 92.8% of these patients were found to have a patent dorsalis pedis visualized on angiography, and through distal bypass surgery, these limbs were spared. 30 patients did not have a dorsalis pedis artery visualized on angiography but did have a Doppler signal and actually explored these patients and were able to bypass the diseased vessels in 50% of these patients by blind exploration surgery.

Bypass Surgery

The bypass surgery to the dorsalis pedis artery is relatively very safe. In this study, there was a 1.8% operative mortality, an incidence of 5.5% perioperative incidence of myocardial infarction, and the patency rate was the same for in situ, reversed or translocated autogenous vein grafts. The valves in the veins were divided using a LeMaitre valvulotome inserted into the distal vein and the surgeon ran it up to the groin and pulled it back to afford anti-grade flow in the venous conduit so that any interference of blood flow from the valves is diminished. Any type of vein bypass used to the dorsalis pedis artery was very effective in saving limbs. (J. Vasc. Surg. 1996; 21: 375-84). The 5-year primary patency rate was 68%, the 5-year secondary patency rate was 82% and the 5-year limb salvage rate was 87%. A patent posterior tibial artery can be extremely effective in distal bypass and limb salvage.

Other Surgical Options include:

• The standard bypass grafts very commonly performed by general or vascular surgeons. Failure of these is usually due to one or more of the following complications: a suboptimal conduit usually due to poor vein quality, myointimal hyperplasia and/or progressive atherosclerosis.

• Thromboendarterectomy was the first technique used for the treatment of aortoiliacocclusive disease (AIOD). Over the years aortobifemoral bypass grafting using synthetic grafts replaced thromboendarterectomy as the standard technique to manage AIOD. Nonetheless, in special circumstances, it still plays a vital role in the surgical management of these patients.

• Rotational atherectomy, a new procedure that involves a less traumatic removal of plaque, is now available.

• Amputation of all or part of the lower extremity is indicated if gangrene or infection threatens the patient's overall health and life and all attempts at medical, interventional, or surgical re-vascularization attempts have failed.

In addition, there are three other circumstances that warrant amputation:

Data indicates that all patients with PVD should be on anti-platelet therapy unless otherwise contraindicated.

• Functional salvage cannot be obtained by the expected result of healing a wound or a lower level amputation. Sometimes if a lower level amputation is performed, the patient will not be able to ambulate as well as if a below-the—knee amputation is performed and the patient is prescribed a prosthesis. Also, healing a wound can leave such a deformed foot, as in calcanectomies for osteomyelitis, that proper shoes and a proper ambulating surface cannot be had

• If the patient's lifestyle does not warrant the effort and expense of saving the limb, as in non-ambulatory patients with limited consciousness.

• If the patient has an open wound and healing the wound would be so time-consuming and costly, that amputation would be in the best overall interest of the patient.

Amputation sometimes will be the quickest way to a patient's recovery of an active and useful lifestyle and is sometimes in the patient's best interest and the best treatment available for that patient. Amputation is not something that always should be avoided.

Interventional Options

An open artery is better than any medication. If that is possible, then opening the artery should be the goal. Limb salvage endovascular interventional procedures such as angioplasty can last a long time, in some cases up to 20 years, in spite of the most common objection to these techniques, that they do not last a long time.

Nevertheless, correction of even moderate ischemia will improve healing and decrease recurrence in the biologically compromised foot. Furthermore, short-term perfusion may salvage a limb long-term. Early detection, therefore, is crucial to saving limbs.

Endovascular and interventional therapeutic procedures fall into the following categories:

a. Peripheral transluminal angioplasty

b. Peripheral stenting

c. Laser techniques

d. Atherectomy used commonly as an adjunctive therapy

e. Thrombolytic therapy is also useful as an adjunctive therapy, especially as it applies to salvaging failed bypass grafts.

The advantages of endovascular therapy before surgery is attempted:

1) Arteries can be accessed that cannot be accessed with surgery.

2) There is less pain, cost, and risk of infection.

3) It's all done through a needle stick.

4) There is a tendency to intervene earlier because of less risk and morbidity.

5) There is preservation of the veins. This is important should these veins be needed in the future for cardiac bypass surgery.

6) There is less trauma to the patient and can be done on an outpatient basis.

Most procedures can be performed in only a few minutes. Multiple segments of disease can be treated at one session. There is less risk of permanent distal complication, including impotence. In addition, atherosclerotic dis-

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ease is often a progressive disease and interventional endovascular procedures can be repeated. It should be noted that the newer interventional techniques are considered low risk procedures, especially when compared with common surgeries done routinely, like hip replacement surgery. Failure of the procedures rarely worsens the limb status and for most people this is the best or only option available to them.

A successful intervention requires four elements. One has to have access to the artery, getting into the artery. This first element is quite simple. However, the second element is the ability to cross the blockage. In the past, this was very difficult and was previously done with lasers and ultrasonic devices with less than optimal results and was very expensive. Today 97% of chronic total occlusions that are 25 cm or longer and have been there at least two years angiographically can be crossed with only a simple inexpensive glidewire or glidecatheter.

Once the blockage is crossed, the vessel then must be opened and kept open. This requires ballooning and a mechanical device like a stent to hold the vessel open. Then the patency of the vessel must be maintained. That's where the old stents failed miserably. But stenting technology has changed. Nitinol stents and self-expanding stents are now used very effectively and outcomes have improved tremendously. Medications play a very valuable role in the periphery, especially anti-clotting medications. In the periphery, anti-clotting medications are more important than in coronary circulation because of the difference in the velocity of blood flow.

In the peripheral circulation, the blood flow is very slow as compared with the cardiac circulation. When blood flow is slower, it has a tendency to clot more readily. As an adjunctive therapy in angioplasty, anti-clotting drugs are important to protect against platelet adherence to the vessel wall and ultimately the production of clots. Areas that are denuded from the trauma of the procedure are exposed to circulating platelets and this can precipitate a clot.

Multi-segmental problems are those in which pathology is involved in more than of the following: aorta, ileac, femoral, superficial femoral and below the knee. Interventions exist that address each affected area. Using stents in Aorta-iliac disease, there are studies that show up to 99.2% immediate clinical success, a two-year clinical benefit of 84% and a 69% clinical benefit after 43 months (Cardiovascular Interventional Radiology 1992;15:291-297). The results of femoropopliteal angioplasty and/or stenting traditionally are not as good as ileac artery angioplasty and/or stenting. If a stent remains open for 6 months, it will usually remain open. It is the first six months that are critical.

Use of Stents

The problem that plagues the superficial femoral artery is re-stenosis because of diminished flow to the artery. Current work being successfully done with Nitinol stents in conjunction with angioplasty and thrombolytics shows promising results. In a 1996 study by Chatelard, et al (J. Cardiovascular Surgery 1996;37(3 suppl /I):67-72), 80% of the patients showed patent arterial flow at the stent site after one year using newer-type stents. It is a common misconception that one can never intervene in infrapopliteal disease, but infrapopliteal intervention with long occluded segments of infrapopliteal vessels using angioplasty has been very successful in patients deemed inoperable.

Balloon expandable coronary stents have been used successful to clear blockages of small vessels like the tibial peroneal trunk. Thrombolysis is considered essential in occluded grafts, be it veins or Gore-Tex grafts, it can be critical in occluded aortas, ileac and superficial femoral arteries to lessen the likelihood of embolic sequellae, and it can be useful in re-perfusing after embolic events.

Potential Complications of Intervention

1) Hemorrhage and hematoma are very rare especially when vascular closure devices are used. Before these devices were used these were the Achilles heel of interventional procedures.

2) Renal Failure: once one becomes accomplished at peripheral intervention, they use less dye and contrast dye is directly related to renal complications.

3) Stroke, myocardial infarction, CHF, reaction to contrast media, peripheral embolus and dissection of the vessel wall are all extremely rare complications.

4) Limb-loss or amputations almost never occur but there is still a minor risk present.

5) Death from co-morbid conditions can always occur when the stress of any intervention or surgery is superimposed on a person who is medically unstable.

Intervention should be attempted before surgery but

Continued on page 134

PVD...

should never take away a surgical option. Newer stents and medications will continue to improve interventional outcomes in the future. Amputations due to ischemic disease will become a rare event when all the new team techniques are reapplied to re-vascularization. Interventional endovascular procedures can be as simple as crossing the blockage with a glide wire to the reconstituted vessel, and then performing the balloon inflations.

These are sometimes multiple because the longest balloon made is only 10 cm long and some occlusions are much longer. Then a self-expanding stent is used to maintain patency of the vessel. This does not take the options away from bypass but can give equally good results. Cutting balloon angioplasty can be used in severely occluded arteries that are diseased all the way down from the infrapopliteal area to the foot to accomplish dilation and create patent vessels in arteries hard to access surgically. Self-expanding stents, effective in preventing re-stenosis, are then put in place. If the results are pristine after balloon angioplasty, then stents are not always used. If there is an element of traumatic dissection then stents are used.

Addendum

There are two modalities that show promise in the treatment of peripheral vascular disease, especially in the outpatient or home setting because of their ease of application. These modalities are the **Diapulse® machine** and the **"Arterial Assist Device"®**. These can be considered if medical, surgical or interventional procedures are not available to the patient, if the patient is not a candidate for other therapies, or to act in concert with other treatments.

Intermittent pneumatic compression (IPC) of the foot, calf or both, an established method of deep-vein thrombosis prophylaxis, has been shown to be effective in improving blood flow to the lower extremity. The *"Arterial Assist Device"™* applies compression to the foot, ankle and calf up to 120 mm Hg, , has been shown to improve walking ability and peripheral hemodynamics of persons with intermittent claudication, and has demonstrated effectiveness as an adjunct to the treatment of non-healing wounds. This positive effect on blood flow is thought to be largely due to venous outflow enhancement, reduced peripheral vascular resistance, improved collateral circulation, inhibition of veno-arteriolar reflex vasoconstriction creating a larger A-V pressure gradient, as well as the release of endothelium-derived relaxing factor (nitric oxide), producing a vasodilatory effect.

The other therapy that shows promise as an adjunct in the treatment of PVD is the use of non-thermal, pulsed, high frequency electromagnetic energy. This is administered with the use of the *Diapulse® machine*. In peripheral vascular disease, prolonged tissue ischemia caused by external pressure exceeding tissue capillary pressure may be exacerbated by the development of edema. The rate of diffusion of oxygen and nutrients to the cells is decreased due to impaired capillary and micro-circulation and lack of proper oxygenation of tissue. Diapulse accelerates the elimination of edema, permitting improved blood flow, nutrients and re-establishing oxygenation to the tissues. The mode of action of non-thermal pulsed radio waves produced by Diapulse are created through electromagnetic induction. The action of the electrical field on charged particles leads to forced motion of blood cells, thereby improving arterial blood flow and decreasing edema. This creates an environment that is conducive to angiogenesis, another factor in the improved blood flow seen with Diapulse. In addition, through this piezoelectric response to Diapulse, it appears that damaged cells recover more quickly due to repolarization and increased sodium pump reaction times, making it a valuable adjunct to not only the treatment of peripheral vascular disease but wound healing as well.

A misconception in diabetic patients is that they have untreatable occlusive lesions in the microcirculation.

We are now beginning a new era of limb salvage. Patients at risk for limb loss now have options that were not previously available to them. We, as experts in lower extremity disease, should be meticulous in our patient history and physical and our review of systems, and should be aware of these new options so that every amputation that can be avoided is avoided.

For more information on Diapulse, circle #168 on the reader service card. For more information on Art-Assist, circle #169 on the reader service card.

Suggested Readings and References:

[1] Seminar: New Cardiovascular Horizons and Management of the Diabetic Foot & Wound Healing, New Orleans, Louisiana 2000. Lectures by David E. Allie, M.D., Craig Walker, M.D., Emile Mohler, III, M.D.

[2] Noyez L & Van De Wal, HJ; PeriOperative Morbidity and Mortality of Coronary Surgery After the Age of 70 years, Journal of Cardiovascular Surgery 1989; 30 issue 6: 981-984.

[3] Akbary, CM & LoGerfo, FW; Diabetes and Peripheral Vascular Disease, Journal of Vascular Surgery 1999, 30 issue 2: 373-384.

[4] Pomposelli, FB Marcaccio EJ; Dorsalis Pedis Arterial Bypass, Journal of Vascular Surgery 1995, 21 issue 3: 375-384.

[5] Palmaz, JC & Laborde, JC; Stenting of the iliac arteries with Palmaz Stent, Journal of Cardiovascular Interventional Radiology 1992, 15, issue 5: 291-297.

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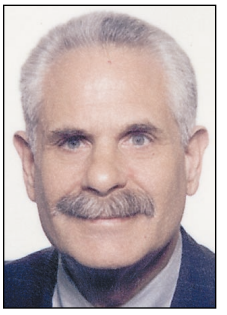
[8] Darling RC 3rd, Shah DM, Chang BB, Lloyd WE, Paty PS, & Leather RP; Arterial Reconstruction for Limb Salvage: Is the Terminal Peroneal Artery a Disadvantaged Outflow Tract? Journal of Surgery, 1995 October 118(4): 763-767.

[9] Kenneth Ouriel, M.D; Acute Limb Ischemia: Management Strategies Seminars in Vascular Surgery Vol. 14 No. 2 June 2001.

[10] Ernst & Stanley; Current Therapy in Vascular Surgery Fourth Edition, Pages: 447-557.



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EXAMINATION

See answer sheet on page 137.

1) All of the following are critical elements in prevention of amputations except:
- A) Identifying loss of protective sensation
- B) Prevention of abnormal pressures during gait
- C) Identifying and treating critical ischemia in the lower extremity.
- D) Vitamin D supplementation

2) All of the following are signs of critical ischemia except:
- A) rest pain
- B) ischemic ulceration
- C) muscle atrophy
- D) pseudoclaudication

3) Which of the following is a key differentiating marker between true vascular disease and conditions that mimic vascular disease?
- A) Onychodystrophic toenails
- B) Lack of dorsalis pedis pulse
- C) Post inflammatory hyperpigmentation
- D) Symptoms elicited without activity, effort, elevation or dependency

4) Common causes of lower extremity arterial occlusive disease include all of the following except:
- A) Hypercholesterolemia
- B) Cardiac disease
- C) Cauda equina syndrome
- D) Hyperlipidemia

5) Which of the following is a true statement in regard to peripheral vascular disease?
- A) The mortality rate of PVD falls below that of Hodgkins disease and breast cancer
- B) Only the quality of life and not the life span is affected by peripheral vascular disease
- C) Limb ischemia is unrelated to carotic and renal disease
- D) The chance of dying from an acute coronary occlusion is the same as from occlusive disease of the lower extremities

6) The following specialists are critical to the treatment of PVD except:
- A) the urologist
- B) the angiographer
- C) the primary care physician
- D) the podiatric physician

7) Which of the following statements are not true?
- A) Calcification of the arteries is the most common cause of obstruction in the peripheral arterial tree
- B) Peripheral vascular disease is a marker of death
- C) The presence of PVD is increasing in society
- D) Physicians are unaware of the presence of PVD in 70% of their patients

8) When a patient is seen with severe peripheral vascular disease, the following questions have to be asked except:
- A) What is the vascular diagnosis?
- B) Is there evidence of venous stasis dermatitis?
- C) Is the problem severe enough to warrant direct therapy?
- D) Is surgical or non-surgical treatment indicated?

9) Before any surgical or endovascular interventional procedure is performed, the physician needs to know the following:
- A) the amount of edema of the lower extremities
- B) the amount of diabetic small vessel disease
- C) whether the outflow vessels can handle a new volume of blood
- D) results of segmental plethysmography

10) Peripheral arterial blockages occur commonly in all of the following areas except:
- A) Medial plantar artery
- B) The common iliac arteries
- C) The superficial femoral artery
- D) Infrapopliteal area

11) Which of the following statements are not true ?
- A) Good intervention starts with good angiography
- B) A single bolus injection angiogram is the study of choice
- C) It is important that oblique angiographic views be taken
- D) The contrast dye may take a longer period of dye to reach the foot than what is standard procedure

12) The standard of care in treating PVD involves all of the following except:
- A) Peripheral nerve blocks
- B) Medications
- C) Surgical procedures
- D) Endovascular procedures

13) Risk factor modification for the treatment of peripheral vascular disease involves all of the following except:
- A) Adequate health insurance
- B) Minimizing lifestyle limiting factors
- C) Control of contributing diseases
- D) Controlling cholesterol

14) The medications used to treat peripheral vascular disease fall into the following categories except:
- A) Vasodilators
- B) Serotonin uptake inhibitors
- C) Thrombolytic agents
- D) Anti-platelet medications

15) The following medications have anti-platelet activity except:
- A) Aspirin
- B) Cilastazol
- C) Clopidogrel
- D) ACE inhibitors

Continued on page 136

Continuing Medical Education

EXAMINATION

(cont'd)

16) Anti-platelet activity is important because of all of the following reasons except:
- A) decreases cholesterol and provides vasodilatation
- B) decreases fibrinogen linking
- C) decreases platelet aggregation
- D) prevention of atherosclerotic buildup in the artery

17) Controlling diabetes is an important part of treating peripheral vascular disease because of all of the following except:
- A) Uncontrolled diabetes accelerates atherosclerosis by 200-400%
- B) Uncontrolled diabetes accelerates the buildup of HDL
- C) Rigid control of blood sugars can decrease the severity of complications and the accelerated atherosclerotic process
- D) The Lipid profile can be modified by using the hypoglycemic agents that work best for the individual

18) The following statements are all true except:
- A) The most common cause of hospitalization in the diabetic population is due to diabetic foot problems
- B) One half of every amputation performed in the U.S. is done on a diabetic patient
- C) 15% of all diabetics will experience foot ulceration in their lifetime
- D) Even though a critical event, amputation is not a common occurrence in the United States

19) Regarding peripheral vascular disease in the diabetic patient, the following statements are true except:
- A) Small vessel disease is the main pathology in diabetic PVD
- B) The diabetic has a specific atherosclerotic pattern
- C) The infrageniculate vessels are often occluded
- D) Diabetic patients rarely have untreatable occlusive disease in the microcirculation

20) Surgical options for peripheral vascular disease include all of the following except:
- A) Dorsalis pedis arterial bypass
- B) Creating an arteriovenous shunt
- C) Blind exploration surgery
- D) Thromboendarterectomy

See answer sheet on page 137.

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Metatarsalgia
(Sobel/Levitz)

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1.	A	B	C	D	11.	A	B	C	D
2.	A	B	C	D	12.	A	B	C	D
3.	A	B	C	D	13.	A	B	C	D
4.	A	B	C	D	14.	A	B	C	D
5.	A	B	C	D	15.	A	B	C	D
6.	A	B	C	D	16.	A	B	C	D
7.	A	B	C	D	17.	A	B	C	D
8.	A	B	C	D	18.	A	B	C	D
9.	A	B	C	D	19.	A	B	C	D
10.	A	B	C	D	20.	A	B	C	D

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EXAM #3/02
PVD
(Rehm)

Circle:

1.	A	B	C	D	11.	A	B	C	D
2.	A	B	C	D	12.	A	B	C	D
3.	A	B	C	D	13.	A	B	C	D
4.	A	B	C	D	14.	A	B	C	D
5.	A	B	C	D	15.	A	B	C	D
6.	A	B	C	D	16.	A	B	C	D
7.	A	B	C	D	17.	A	B	C	D
8.	A	B	C	D	18.	A	B	C	D
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