CHAPTER **44**

USE OF ARTERIOGRAPHY IN PODIATRIC MEDICINE

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Arteriography is an effective study that allows the physician to see the current course of blood flow through the body. As with any diagnostic tool, the purpose of the test should be to confirm the diagnosis that was already made based on clinical observation. Arteriography can not only confirm several pathologies, but more importantly, can show the location and extent of the vascular abnormality.

Arteriography is rarely a first line diagnostic test. Many noninvasive vascular tests can initially be used to determine blood flow. Because arteriography is an invasive exam, there are associated risks ranging from a simple hematoma from the vascular intrusion, to anaphylactic reaction from the imaging dye. Most risks associated with arteriography can be minimized with careful technique and thorough history. The indications for using arteriography in the lower extremity are varied. Generally speaking, an arteriogram should be used anytime a precise picture of the arteries and their function is needed.

HISTORY

X-rays were discovered by Roentgen, in 1895. This discovery eventually led to the process of injecting radiopaque dye into the blood vessels, and to the modern process of arteriography.[1] In 1896 Becker, was able to radiographically outline the stomach of a pig by using lead acetate. Cannon, in 1896 successfully used bismuth sub-nitrate in food to study peristalsis on fluoroscopic exam. Haschek and Lindaw were the first to use a radiopaque substance to produce an image of the blood vessels in the hand, albeit, in a cadaver. In 1906, Voelker and Lichtenberg introduced retrograde pyelography, and in 1924 Brooks reported the use of sodium iodide to show the vascular network in the lower extremity of man.[2] Advances in arteriography have continued, and today virtually any blood vessel in the body can be clearly imaged.

INDICATIONS FOR ARTERIOGRAPHY IN PODIATRIC MEDICINE

There are multiple indications for use of arteriography in podiatric medicine including 1. Chronic or acute vascular occlusions, 2. Vasospastic disorders, 3. Evaluation of tumors, 4. Trauma, and 5. Determination of the vascular supply to previous reconstructive surgery sites.[3] The most common use of arteriograms is for vascular lesions, and femoral arteriography is the most common study performed in hospitals.[4]

Vascular Occlusions

Chronic Vascular Occlusions. Atherosclerosis is one of the most common vascular diseases encountered in podiatric medicine. The appearance of symptoms of atherosclerosis are usually gradual in nature, and most patients present to the doctor only when the disease is in the advanced stages. Common symptoms of advanced disease include intermittent claudication, chest pain, ulcerations, gangrene, and ischemic neuropathy.[5] In diabetic patients, it is common to see atherosclerotic involvement of the tibial and peroneal arteries without involvement of the more proximal large arteries, however this is uncommon in the nondiabetic patient (Fig. 1). It is estimated that approximately 40% of all diabetics have atherosclerosis in the arteries of the foot, and atherosclerosis is the leading cause of death in diabetics (75%).[3]

When a patient presents with symptoms of atherosclerosis, it is important to determine the level and extent of the disease. Initial testing should consist of noninvasive modalities such as Doppler, ankle/brachial indices, or segmental pressures.[1] If the noninvasive tests indicate significant disease, the patient should then undergo a complete lower extremity arteriogram. This test allows the physician to determine the extent and location of the vascular plaques (Fig. 2). The arteriogram and the clinical appearance of the

Figure 1. Atherosclerotic occlusion of artery.

Figure 2. Atherosclerotic plaques.

lower extremity will help determine the treatment options, especially when surgery is being considered. If a bypass is being considered, the arteriogram will show the patency of the vessels and the areas where the bypass will have the greatest chance of success. If the information gleaned from the arteriogram indicates that a bypass is not a viable option and amputation may be indicated, the arteriogram can help determine the proximal limits of the amputation.

Acute Arterial Occlusion. In contrast to the chronic nature of atherosclerosis, acute arterial occlusion can cause severe damage in a short period of time. Timely and accurate diagnosis are critical to prevent the ischemic insult that can quickly lead to necrosis and eventual amputation.

Acute arterial occlusions can be divided into intrinsic or extrinsic forms. Extrinsic forms of acute occlusions are usually the result of trauma. Intrinsic acute arterial occlusions are usually either of a thrombotic or embolic nature. Embolic episodes are generally more severe than thrombotic occlusions. Embolic occlusions usually occur in minimally-diseased arteries, while thrombotic occlusions normally occur in severely-diseased arteries. Examples of pathology from either type of arterial occlusion include blue toe syndrome, focal tissue necrosis, and even total limb ischemia depending on the availability of collateral circulation.[6]

Diagnosis of acute arterial occlusion begins with a thorough history, especially in regard to cardiac disease such as valve disorders, or arrhythmias. Other areas to consider in the history are any chronic vascular disease such as atherosclerosis, or diagnosed aneurysms.[4] The patient may also relate the six P's of arterial occlusion which are pain, pallor, paresthesia, pulselessness, paralysis, and polar.[6]

The next step in diagnosis is the physical examination which should include palpation, laboratory studies, and noninvasive vascular studies. Results from these tests and the physical appearance of the leg allow for the possibility of a definitive diagnosis and treatment. In some cases, the diagnosis of acute arterial occlusion may not be clear, or the site of the occlusion may not be apparent. Arteriography is indicated for arterial occlusion when a definitive diagnosis is needed along with information about the exact location of the occlusion. The arteriogram will also reveal the extent of collateral circulation and the patency of the distal arteries, which shows the extent of the occlusion.[6]

An embolism that causes a complete occlusion has a characteristic appearance on the arteriogram.

The proximal end of the occlusion has a curved margin extending convexly into the vessel lumen. Collateral circulation is generally absent when the occlusion is acute. The appearance of an embolism that only causes partial occlusion looks like a filling defect due to the contrast material that flows around the embolus.[4]

Treatment for the occlusion will be based on the information gathered from the examination and studies. Options range from conservative measures such as drug therapy with urokinase, streptokinase or TPA[7] to surgical options such as thrombectomy, and amputation in extreme cases.

Vasospastic Disorders

Vasospastic disorders include disease entities such as Raynaud's phenomenon, livedo reticularis, acrocyanosis,[8] and arterial spasm.[1] Raynaud's phenomenon is one of the most common vasospastic disorders encountered in podiatric medicine. This condition is usually of idiopathic origin and can occasionally be from a secondary cause such as trauma, scleroderma, or even vascular occlusion. Occlusive episodes usually result from an exposure of an extremity to cold temperatures. The digits become numb and turn white, then blue. In time, the blue color of the skin becomes red and hyperemic, and the numbness becomes a throbbing pain. The vessel in spasm can be visualized on the arteriogram as being a uniformly tapering vessel until the vessel is not seen. The arteriogram can be used to determine the level of vasospasm, especially when it occurs in the small arteries of the foot[8] (Figs. 3A, 3B).

Soft Tissue Masses and Bone Tumors

Arteriography can also be an effective tool in the diagnosis and treatment of soft tissue masses and bone tumors, although they are nonspecific for tissue types. Arteriograms can show the size of the mass, location of the feeder vessels, relationship of the mass to other soft tissues (especially blood vessels), and can help in planning the surgical approach. Some authors believe that arteriography can assist in the identification of bone tumors as well, however it is more beneficial in identifying potential extension of the tumor into the soft tissues.[9,10] Arteriography is especially useful when trying to differentiate between soft tissue masses and vascular anomalies such as cavernous hemangiomas[11] (Figs. 4A, 4B) and arteriovenous malformation (Fig. 5).

Today MRI is commonly used to image soft tissue masses. However, the image can often look homogenous, and it can be difficult to tell exactly where the malignant tissue lies. According to Levin

Figure 3A. Postoperative foot in vasospasm.

Figure 3B. Postoperative foot after the administration of a vasodilator.

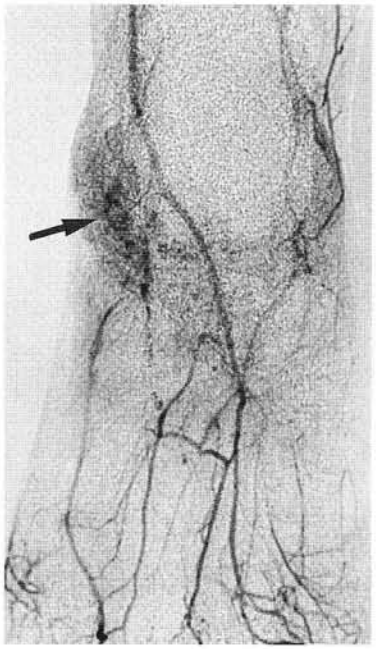

Figure 4A. Dorsoplantar view of a cavernous hemangioma.

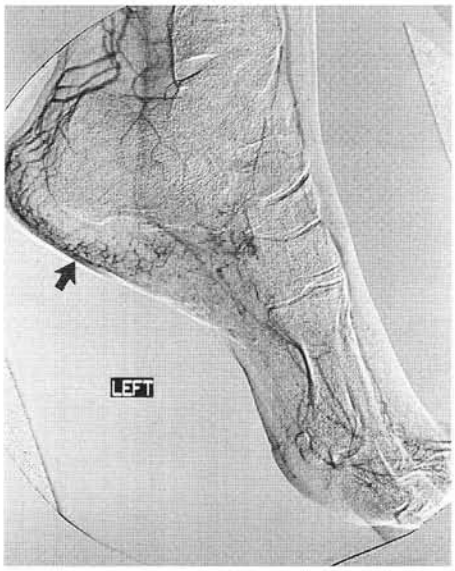

Figure 4B. Lateral view of the cavernous hemangioma in Figure 4A.

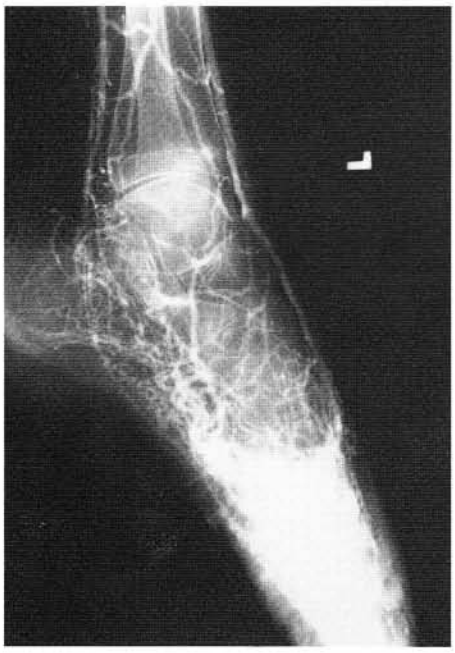

Figure 5. AV malformation.

10% of biopsies of malignant tumors are misdiagnosed due to poor selection of the biopsy site location. Arteriography can be used to help locate the best site for biopsy. Generally, the area of increased vascularity corresponds with the most malignant part of the tumor. The vessels in malignant lesions will usually have a random, and unusual course. The vessel walls are ragged, very coarse, and end sharply at the margin of the tumor. In some instances there will be straight vessels that run in right angles to the normal pattern.[12]

Arteriovenous shunting is also seen in malignant tumors. Tumors that tend to be less vascular have only small vessels.[10] Arteriography has other uses in the treatment of tumors such as determining the site of amputation if it is needed and in determining the presence of any potential satellite lesions.[9]

Trauma

Arteriograms are useful in determining the status of vascular damage due to direct vessel trauma, or lack of function due to excessive pressure. According to Perry, "in the management of trauma patients preoperative arteriography is used for three main reasons: 1. to exclude the presence of a vascular injury in a patient who otherwise has no indications for operative exploration, 2. to detect a lesion that was not exposed by other diagnostic

techniques, and 3. to plan the operative management of a patient with a major vascular injury."[12]

Trauma occurs most commonly as a result of a direct penetrating injury such as a bullet wound, or as a result of a fracture of an adjacent bone. Fracture of heavy bones such as the tibia can release large amounts of energy and the trauma to the soft tissues in the adjacent area can be equal to that caused by high velocity bullets.[12]

Arteriography can be performed in the trauma patient in a manner that gives quick reliable results. This procedure is performed via femoral puncture, injecting the dye and then taking an AP film in the area of suspected injury. If possible, two contrasting views are needed to give a better perspective of the injured vessel.[13]

Although not commonly performed at this time, it has been suggested that arteriograms should be used to evaluate the condition of vascularity to certain dislocated bones. The arteriogram would be useful in post-reduction evaluation of bones such as the talus that have a predilection to avascular necrosis. According to A.L. Jimenez, if the vascular status to the talus could be confirmed early, then range of motion exercises could be instituted at an earlier time (personal communication, November, 1995).

Reconstructive Surgery

Arteriography can be utilized when a map of the vasculature is needed to plan a surgical procedure. The arteriogram may be imperative when previous surgery has involved vascularized muscle or bone grafts. Knowledge of the location of the feeding arteries is important (Figs. 6A, 6B). The arteriogram would also be indicated postoperatively to evaluate the condition of a vascular graft.

COMPLICATIONS OF ARTERIOGRAPHY

Arteriography, like most other procedures, has potential for complications. These complications range from a simple hematoma at the arterial puncture site,[14] to death. Serious complications are rare and most of the time the benefits gained by obtaining the arteriogram far outweigh the associated risks.

Complications associated with arteriography usually result from either the contrast material, or from the catheter insertion into the artery. Complications associated with the catheter include: vascular spasm, hematoma, syncope, and thrombosis of an artery. Complications associated with the contrast material are also varied and include hypotension, peripheral vasodilation, myocardial depression, pulmonary edema, bronchospasm, renal failure, and stroke. Renal insufficiency is the side effect that seems to cause the most concern. The exact mechanism of how the contrast material causes the damage is not known. However, there is a relationship between the length of exposure and concentration of the contrast material to renal toxicity. Patients that are at a greater risk for renal impairment include those that have diabetes, preexisting renal impairment, and are dehydrated. Depending on the dosage of the contrast material the incidence of renal insufficiency is 0.6% to 11.3%.[1]

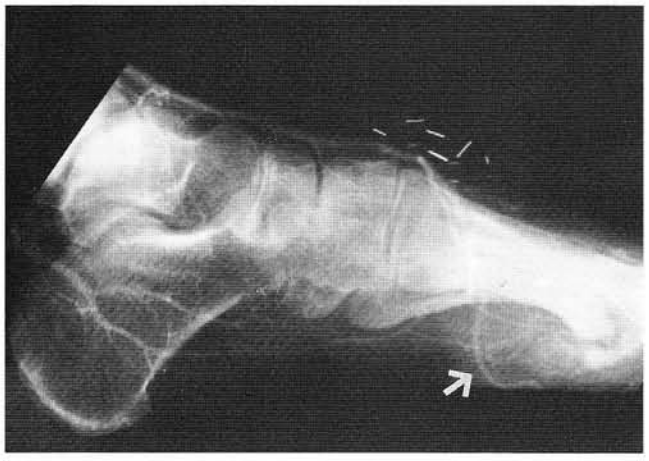

Figure 6A. Arterial supply to a muscle graft.

Figure 6B. Radiograph of the graft site.

PATIENT PREPARATION

Unlike most tests ordered by the physician, an arteriogram takes a great deal of preparation and should be considered to be a procedure rather than merely a test. All of the preparatory work is intended to reduce the chances of complications.

A thorough history and physical needs to be taken prior to the arteriogram. Emphasis should be placed on determining if the patient had any previous complications with similar studies. Laboratory evaluation should include renal function tests, and coagulation studies.[1]

On the day of the arteriogram, the patient should be NPO for eight hours prior to the beginning of the procedure. Hydration of the patient will help prevent renal damage. The patient should receive intravenous fluids before and after the procedure. Patients with elevated creatinine levels should be given mannitol intravenously to establish an osmotic diuresis. This dieresis will also reduce the chance of renal damage. Patients who have had reactions to the contrast materials can receive steroid preparations with the contrast material to prevent further reactions.[1]

CURRENT IMPROVEMENTS IN ARTERIOGRAPHY

Two recent major advances in arteriography are digital subtraction arteriography and magnetic resonance arteriography. Digital subtraction arteriography (DSA) is an invasive technique which uses contrast dye in the same way as conventional arteriography, however DSA has the ability to eliminate the background images on the film and hence focus more on the blood vessels. DSA works by using an image intensifier which ultimately stores the images in the computer. The images are taken before the contrast is applied and continue through the entire process. After the images are stored, the computer can compare the images without contrast to those with contrast, and subtract out the nonvascular images. DSA is able to show smaller vessels then conventional arteriography, and requires less then one half of the contrast material making it safer for patients with renal disease. DSA is also much faster then conventional arteriography.[1,15]

Magnetic resonance arteriography (MRA) is a noninvasive form of arteriography. Advances in MRI technology allow for imaging of peripheral vessels. No contrast material is needed. In a study where conventional arteriography was compared to MRA, the MRA studies were found to be more sensitive and at an equivalent cost.[15]

CONCLUSION

Arteriography is a valuable diagnostic tool that has many uses in podiatric medicine. Although there are risks associated with arteriography, these can be minimized by careful preparation and patient selection.

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