International Journal of Science and Research (IJSR)
ISSN: 2319-7064
SJIF (2022): 7.942

Lower-Extremity Peripheral Artery Disease Imagery

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Abstract: ***Peripheral arterial occlusive disease (PAD) is the narrowing or occlusion of an artery or arteries of the limb. Most commonly caused by atherosclerosis, less common causes include thromboembolism, trauma, entrapment syndromes and vasculitis including vasospastic disorders and buerger's disease. Disorder of the arterial system produces complications ranging from minor disabilities to loss of the limb. Acute peripheral arterial occlusions usually involve the infrainguinal segment. The essence of atherosclerotic disease lies in intraluminal stenosis, impeding blood circulation and causing acute thrombosis. Emboli usually lodge at bifurcations, but may also involve arterial segments, resulting in turbulent distal flow and impaired tissue perfusion. This disease is an independent risk factor for vascular disease in other regions, resulting in an increased chance of cardiovascular events and increased mortality. It negatively affects the functional condition of the limbs, causing a decrease in the quality of life. Therefore, early diagnosis and effective treatment is usually rewarded with good outcome and averts dreadful complications. Conventional digital subtraction angiography is considered as the gold-standard technique.***

Keywords: Peripheral Arterial Disease, Colour Doppler Ultrasound, Computed Tomographic Angiography, Stenosis

1. Introduction

Peripheral vascular diseases (PAD) are diseases that affect the vascular system, and not the heart or brain. The first line of vascular disease management is interventional treatment. Interventions aim at revascularization or intentional occlusion of the affected vessel. The treatment of patients with endovascular techniques has constantly evolved. These patients can be treated by interventional radiologists in their private clinics, or by multidisciplinary teams composed of vascular surgeons, radiologists, angiologists and/or cardiologists. In this dynamic health system, treatment by multispecialist groups is the best approach and the most financially affordable alternative. Nowadays the role of non-invasive imaging has increased significantly, better determining the extent of peripheral vascular disease. Correlation of clinical data with anatomical data allows the interventional radiologist to adequately determine the patient's treatment plan. Open surgery for PAD has now been replaced by minimally invasive interventions. In this way, the recovery time is reduced, the return to work is faster and the overall health costs are lower. Interventional radiology is very useful in the treatment of the diabetic foot. All specialists in this field must work in a multidisciplinary team with dedication and professionalism, in national centers of excellence with well-defined criteria. It is very important to follow new endovascular developments in time, without forgetting the principles of evidence-based medicine. In the future, specific programs for the diabetic foot and dedicated personnel should be drawn up, since it is expected that the costs and the disease will increase in the following years. Lower-extremity peripheral artery disease (PAD) (atherosclerotic disease of the lower extremity arteries; lower-extremity artery disease) is estimated to affect 8.5 million persons in the United States who are older than 40 years and 202 million people worldwide. Lower-extremity PAD includes disease of the aortoiliac, femoropopliteal, and infrapopliteal arterial segments. (1)

Only about 10% of people with PAD have the classic symptom of intermittent claudication. Approximately 40% are asymptomatic, and the remaining 50% have a variety of leg symptoms different from classic claudication. Over time, patients with PAD experience a significant decline in function of the lower extremities. (2)

The American Heart Association/American College of Cardiology (AHA/ACC) have identified the following risk factors for lower-extremity PAD (1):

- Age ≥65 yr
- Age 50-64 yr with risk factors for atherosclerosis (eg, diabetes mellitus, history of smoking, hyperlipidemia, hypertension) or family history of PAD
- Age < 50 yr with diabetes and at least one additional atherosclerosis risk factor
- Known atherosclerotic disease in another vascular bed (eg, coronary, carotid, subclavian, renal, mesenteric artery stenosis, or abdominal aortic aneurysm)

Preferred Examination

Noninvasive hemodynamic tests such as the ankle brachial index (ABI), toe brachial index (TBI), segmental pressures, and pulse-volume recordings (PVR) are considered to be the first imaging modalities necessary to reliably establish the presence and severity of arterial obstructions. The first step in imaging assessment of a patient with lower-extremity atherosclerotic arterial disease is to record pulse-volume (plethysmography) and blood pressure measurements in the upper and lower extremities to compare the pressures. An ABI of less than 0.95 is a strongly predictive sign of lower-extremity perfusion compromise. This noninvasive test provides information regarding the intravascular blood flow at different sites of the leg (upper thigh, lower thigh, above the ankle) as a waveform. Triphasic readings are normal and change to biphasic or monophasic in the diseased state. (3, 4, 5, 6, 7)

2. Material and Methods

This is a systematic review of te literature search in the international electronic databases of Web of Science, PubMed, Scopus, Cochrane Library, Google Scholar and Embase we researched to find relevant articles using medical subject headings and specific keywords.

3. Results and Discussion

Doppler ultrasonography (US) has become the second-line test in the evaluation of lower-extremity arterial disease. Doppler US findings provide good information about the anatomy and physiology of the vessels. Spectral Doppler ultrasonography and color flow vascular imaging supplement gray-scale US in identifying blood vessels, confirming the direction of blood flow, and detecting vascular stenosis or occlusion. (8, 9, 10, 11, 12) Doppler US is inexpensive and widely available but does not offer detailed description of the length, severity, or type of the diseased portion of the vessel, all of which help in planning surgical or endoluminal intervention. Although vascular mapping can be performed to evaluate the iliac vessels and the femoropopliteal arterial segments, it is time and labor consuming (with examinations sometimes requiring as long as 2 hr). It is also operator dependent. (13)

Arteriography remains the most accurate and informative test, but it is considered an invasive diagnostic method. This examination is associated with complications such as hematoma at the puncture site; complications due to radiation exposure, intimal flap dissection, or arterial wall rupture; and nephrotoxicity due to the intravenous contrast material (which poses greater risk because of the common association of lower-extremity PAD with renal arterial disease and renal disease). Therefore, arteriography is preserved for preoperative evaluation only. (14, 15, 16) Digital subtraction arteriography is the most accurate test used to define the anatomy and degree of pathology, but it is indicated only when intervention is considered. It is commonly performed using an isosmolar, nonionic, iodinated contrast agent with ionizing radiation. CT angiography (CTA) and MRA are quite comparable in visualizing vessels and can provide much of the diagnostic information of the lower-extremity arteries that can be obtained with conventional angiography. CTA provides higher resolution and can scan the entire volume quickly. It allows evaluation of arterial calcium, vascular stents, volume rendering, and imaging unstable patients. A prospective study comparing CTA, MRA, and digital subtraction angiography (DSA) showed similar diagnostic accuracy. Generally, CTA is the preferred imaging modality for planning endovascular interventions for abdominal and thoracic aortic aneurysms and lower-extremity arteries. (14, 15, 16, 17) Contrast-enhanced arterial CT is evolving in the diagnosis and treatment of lower-extremity vascular disease. Disadvantages of conventional CT include the use of ionizing radiation and the requirement for contrast materials. (18) MRA is noninvasive, it does not require the use of ionizing radiation, and the contrast agent used is relatively non-nephrotoxic. MRA is a fast procedure, providing much of the diagnostic information that can also be derived from catheter angiography with less risk. MRA is generally used in young patients and in patients with contrast allergy or renal insufficiency. MRA should not be used in patients with a pacemaker and other implants. MRA is not effective in unstable and uncooperative patients. This modality is associated with limitations such as its cost, its availability, the limited depiction of small vessels, its contraindications, and the possible overestimation of the degree of stenosis. (14, 15)

4. Diagnosis

A comprehensive medical history and physical examination are essential for determining the existence of PAD in patients with DM. During a physical examination, blood pressure should be measured, and the peripheral pulses should be palpated at the femoral, popliteal, and pedal vessels. It is beneficial to have information on the symptom onset and duration, pain characteristics, and any mitigating factors. However, leg pain and functional impairment may also be secondary to diabetic neuropathy (16). The Fontaine scale can be used to classify the clinical stages of symptomatic PAD. Fontaine stage-I patients have PAD but are asymptomatic; patients at stages IIa and IIb have mild and moderate-to-severe intermittent claudication, respectively; Fontaine stage-III patients have symptoms at rest, and Fontaine stage-IV patients have significant tissue loss (ulcers or gangrene) (17). The ankle-brachial index (ABI) is used to confirm the diagnosis of PAD in individuals after collating an adequate history and physical examination. The ABI is calculated by dividing the higher systolic blood pressure of the right or left arm by the higher systolic blood pressure of the posterior tibial or dorsalispedis in each leg. An ABI of 0.90 is sensitive and is specific for arterial stenosis, and is also diagnostic for PAD, whereas further testing may be required in diabetic individuals (18). An ABI after exercise testing may provide additional information for people with the relevant symptoms and a normal ABI. The ABI is limited in mediocalcinosis, which typically occurs in patients with DM. Diffuse calcification of the arterial wall may cause the tibial artery to become incompressible, limiting systolic pressure measurement at that location despite inflating the blood pressure cuff up to 250 mmHg; in consequence, stenotic lesions cannot be detected by the ABI. In this situation, other noninvasive tests, such as the measurement of the toe-brachial index (TBI) or Doppler waveform analysis may reveal vascular occlusive disease, despite a falsely elevated ABI (19). The measurement of TBI is important in this context because digital vessels rarely calcify and can provide an accurate assessment of vascular disease in the presence of calcification. As with coronary arteries (20), the peripheral fractional flow reserve can be measured invasively via stenosis with a pressure wire; although there have been several promising attempts, technical drawbacks, such as unknown cut-off values and unknown optimal papaverine/adenosine doses, have made this measurement unpopular in terms of peripheral vasculature (21). Invasive angiography remains the gold standard for diagnosis, but over the past decade, there has been an increasing reliance on noninvasive imaging studies to diagnose PAD. Ultrasonic duplex scanning can directly visualize the vessels, providing information about the thickness of the arterial wall, the degree of flow turbulence, and changes in blood flow velocity. With the introduction of

magnetic resonance (MR) angiography and computed tomographic (CT) angiography, non-invasive imaging is now a reality. Contrast-enhanced magnetic resonance angiography produces images that are comparable to conventional angiography. More recently, the development of CT angiography has dramatically improved image quality and expanded the applications of non-invasive angiography (22). Between 2002 and 2013, a study found that among radiologists, MR and CT angiography almost replaced invasive angiography in the diagnosis of PAD. However, the phenomenon was not uniform, as the use of invasive angiography increased sharply among cardiologists and surgeons despite there being available noninvasive alternatives (23). This figure demonstrates the need for unanimity among specialties and for the introduction of these tests in consensuses and guidelines. Moreover, volumetric CT perfusion has recently shown promising results in the assessment of PAD before and after revascularization (24), while a new MR perfusion protocol reliably differentiated patients with PAD from healthy controls (25). The laser Doppler blood flowmeter is another useful noninvasive tool for detecting PAD at an early stage by recording skin perfusion deterioration (26).

5. Conclusion

Peripheral vascular disease commonly referred to as peripheral arterial disease (PAD) or peripheral arterial occlusive disease refers to obstruction of the arteries of the extremities. Since atherosclerosis of the lower extremities is a major pathology for systemic atherosclerotic diseases, these patients are at increased risk for systemic morbidity. Acute peripheral arterial occlusions usually involve the infrainguinal segment. The essence of atherosclerotic disease lies in intraluminal stenosis, impeding blood circulation and causing acute thrombosis. Emboli usually lodge at bifurcations, but may also involve arterial segments, resulting in turbulent distal flow and impaired tissue perfusion. This disease is an independent risk factor for vascular disease in other regions, resulting in an increased chance of cardiovascular events and increased mortality. It negatively affects the functional condition of the limbs, causing a decrease in the quality of life. The criterion standard for intraluminal obstruction is arteriography. Delay in performing arteriography in the setting of limb ischemia can result in delayed treatment. If time allows, arteriography can prove useful in discriminating thrombotic disease from embolic disease. Doppler ultrasound studies are useful as primary noninvasive studies to determine flow status. Lower extremities are evaluated over the femoral, popliteal, dorsalispedis, and posterior tibial arteries. Magnetic resonance imaging (MRI) may be beneficial because of its high visual detail. Plaques are easily seen, as well as the difference between vessel wall and flowing blood. MRI may be limited in the emergency setting because of its location and the technical skill required. Benefits of magnetic resonance angiography (MRA) include high diagnostic accuracy and the avoidance of exposure to ionizing radiation; drawbacks include limited availability and increased cost. Computed tomography (CT) can be of use in the emergency department because of its availability. Contrast studies are most useful for imaging arterial insufficiency. PAD often coexists with risk factors for contrast-induced renal failure. High-definition CT studies may help guide treatment decisions. Benefits of CT angiography (CTA) include rapid noninvasive acquisition, wide availability, high spatial resolution, and the ability to generate isotropic datasets on 64-detector-row and higher CT scanners; drawbacks include exposure to iodinated contrast and ionizing radiation. Molecular imaging with radionuclide-based approaches may potentially provide a novel noninvasive assessment of biologic processes in PAD, such as angiogenesis and atherosclerosis.

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