Evaluation Of Peripheral Arterial Disease Of Lower Limb By Duplex Colour Doppler Study

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Abstract:

Introduction: Peripheral arterial disease is the most common condition affecting the arteries of lower extremities, may manifest as claudication, rest pain, local tissue loss (ulceration), and, potentially, amputation. These patients have an increased risk of mortality, myocardial infarction and stroke.

Material & Methods: It was a prospective study. The study was carried out in the Department of Radiodiagnosis, Nataji Subhash Chandra Bose Medical College & Hospital Jabalpur by SIEMENE’S SONOLINE G - 50 Doppler machine by a linear 5–10 MHz probe and a curvilinear 3–5 MHz probe. The study was carried in one year from October 2013 to October 2014. The study consisted of 50 patients.

Results: Among the 50 patients studied, most of them were above 40 years of age (90%). Majority of the patients were males, comprising about 76%. Most common symptom was intermittent claudication and colour changes. Hyper-lipidemia, smoking, hypertension and diabetes were the major risk factors. Most of the lesions involved SFA and PA and more so on right side. Among the patients with atheromatous plaques, 41.3% were moderately echogenic, 37.9% were severely echogenic and 20.6% showed low echogenecity.

Conclusion: Duplex color Doppler sonography can accurately locate the site and extent of stenosis/occlusion. Duplex Doppler imaging is safe, cost effective, repeatable, noninvasive procedure for investigating lower limb arteries. Hence it is the primary investigation of choice in all cases of lower extremity arterial disease and helps to decide the need for further evaluation by angiography. Color Doppler study also helps in the follow-up of the arterial diseases.

Keywords: Peripheral Arterial Disease, Lower Limb, Duplex Colour Doppler

Introduction: Peripheral arterial disease is the most common condition affecting the arteries of lower extremities. Compromise of arterial flow due to stenosis and occlusions can result in limb ischemia, which may manifest as claudication, rest pain, local tissue loss (ulceration), and, potentially, amputation. Patients with PAD may have symptoms but can also be asymptomatic. These patients have an increased risk of thromboembolism, acute mortality, myocardial infarction and stroke. It is an independent risk factor for vascular disease in other regions, resulting in increased rate of cardiovascular events and mortality. It adversely affects the functional status of the limb and is associated with poor quality of life. The most common cause in the lower limb arterial occlusive disease is atherosclerosis. Less common causes include...
thrombotic occlusion, micro embolism, trauma and vasculitis including vasospastic disorders and Beurger’s disease. Atherosclerosis, though typically asymptomatic for decades, eventually produces two main problems: First, the atheromatous plaques, though long compensated for by artery enlargement, eventually lead to plaque ruptures and clots inside the artery lumen over the ruptures. The clots heal and usually shrink but leave behind stenosis (narrowing) of the artery (both locally and in smaller downstream branches), or worse, complete closure, and, therefore, an insufficient blood supply to the tissues and organ it feeds. Second, if the compensating artery enlargement process is excessive, then a net aneurysm results. Not only we can save the limb but improve the function of the limb by diagnosing and treating this condition.²

Arteriography is considered the standard investigation for peripheral arterial diseases. It gives an accurate anatomical description of obstructive arterial lesions. However, it does not estimate the haemodynamic significance of such lesions. Recently, advances in duplex scan have raised the possibility that it could replace arteriography as the primary imaging modality for assessment of limb ischemia.³

Ultrasonic imaging provides a non-invasive assessment of the arterial circulation in the lower limb and is accepted as a valuable diagnostic technique. Grey-scale images identify plaque and thrombus, duplex assessment provides a measurement of blood velocity through a vessel, and colour doppler imaging enables the rapid localization of arterial stenosis and occlusions. Its association with interventional endovascular processing explains its significant development these days. It thus allows the evaluation, the quantification and the follow-up of the arterial diseases by carrying out a precise vascular mapping that can guides the radiological or surgical processing if necessary. Colour Doppler imaging is safe, popular, cost effective, repeatable, noninvasive procedure for investigating lower limb arteries.⁴

Ultrasound currently remains an important modality in the evaluation of peripheral arterial disease, and even if MR angiography eventually becomes the preeminent technique in the evaluation of this disease, Ultrasound will likely continue to have a role in many settings, such as for targeted questions (eg, postangioplasty assessment, pseudoaneurysms), in portable examinations for patients unable to cooperate for MR imaging, and where expensive CT and MR equipment are not available.⁵

**Material & Methods:**

It was a prospective study. The study was carried out in the Department of Radiosigionosis, Nataji Subhash Chandra Bose Medical College & Hospital Jabalpur by SIEMENE’S SONOLINE G - 50 Doppler machine by a linear 5–10 MHz probe and a curvilinear 3–5 MHz probe. The study was carried in one year from October 2013 to October 2014.

The study consisted of 50 patients. Clinically suspected cases of peripheral arterial diseases were included in the study and patients with pregnancy and pediatric patients were excluded

**Duplex ultrasound criteria for arterial evaluation:**

**B – Mode:** Assess ability

- Anatomy ( course, variants )
- Vessel contour ( aneurysm, stenosis )
- Wall thickness ( calcification, plaque )
- Pulsations (axial, longitudinal )
- Perivascular structures (haematoma, abscess, compressing structures)

**Doppler:** Demonstration of flow

- Flow direction, pattern (Laminar, Turbulent), character (Monophasic, Biphasic, Triphasic) and velocity.

**Technical Aspects of Arterial Duplex Imaging:**

The examination is explained and history (risk factors, signs and symptoms) is obtained from the patient. The presence / absence of peripheral pulses and bruits should be documented. Arterial duplex imaging is performed with the patient lying in the supine position on an examination table. Peripheral arterial imaging begins at the level of the aortic bifurcation.

It is best to use a low frequency transducer (2.0-3.5 MHz) for the proximal segment of the examination. The aortic bifurcation is best seen with the patient turned to the left side and with the transducer placed just in front of the right iliac crest in a longitudinal plane. The distal aorta can usually visualize with the origin of both common iliac
arteries. Doppler signals should be obtained from all three vessels at this location.

Turn the patient into a lateral decubitus position (side being evaluated up) to evaluate the internal and external iliac arteries with the transducer placed between the iliac crest and the umbilicus. Doppler waveforms should obtain from the internal and external iliac arteries, noting direction of blood flow and velocity. If difficulty is encountered in locating the iliac arteries from this approach, the arteries may be located by identifying the femoral arteries at the groin level and following the arteries proximally.

The patient returns to the supine position and a higher frequency linear array transducer (5-10 MHz) should be used for evaluation of the arteries of the lower extremity. The common femoral artery is located at the level of the groin. The artery lies lateral to the common femoral vein. Imaging should be performed in the longitudinal plane, and a Doppler signal should be obtained from this artery. The vessel should be followed distally on the leg to the origin of the superficial femoral and profunda femoris (deep femoral) arteries. Doppler signals should be obtained from the origin of both the superficial femoral artery and the deep femoral artery.

The superficial femoral artery is followed distally as it courses down the medial aspect of the thigh. Doppler signals should be obtained along its pathway and at areas of questionable narrowing. The distal portion of the superficial femoral artery may be easier to evaluate from the distal posterior thigh. This artery is followed distally in the limb and becomes the popliteal artery. The popliteal artery should be followed through the popliteal fossa. The popliteal artery lies deep to the vein, and a Doppler spectral waveform should be obtained from this vessel.

Following the distal popliteal artery in a longitudinal plane, the origin of the anterior tibial artery can usually be visualized diving deep on the monitor. The anterior tibial artery can only be followed for a short distance from this approach. The remainder of the vessel can be located distally by placing the transducer on the lateral calf and it can be followed to the level of the ankle. The tibial-peroneal trunk extends into the calf from the popliteal artery.

The posterior tibial and peroneal arteries are usually visualized by placing the transducer on the medial calf. The peroneal artery lies deep and runs parallel to the posterior tibial artery. These vessels are located above the malleolus and followed proximally.

At the end of the arterial duplex examination, the ultrasound gel should be removed from the patient with a clean towel, and any excess gel should be removed from the transducer. The transducer should be cleaned using a disinfectant.

The collected data were analyzed with the aid of calculator and presented in the form of tables, graphs, figures and diagrams wherever necessary. The findings are discussed and compared with findings of other similar studies.

**Results:**

Among the 50 patients studied, most of them were above 40 years of age (90%). In our study, majority of the patients were males, comprising about 76%. Clinical history evaluated during the study showed that the most common symptom was intermittent claudication and colour changes. The next common were coldness, paresthesias, gangrene followed by rest pain.

In the history taken during the study for risk factor evaluation, it showed that hyper-lipidemia, smoking, hypertension and diabetes were the major risk factors. In the study right limb was involved more than left limb. Bilateral limb involvement was observed in 8 patients.

In the study, it was observed that most of the lesions involved SFA and PA and more so on right side.

Among the patients with atheromatous plaques, 41.3% were moderately echogenic, 37.9% were severely echogenic and 20.6% showed low echogenicity.

On categorizing patients based on percentage stenosis, 10% of them showed 1-19% stenotic lesions, 20% of them showed 20 – 49% stenosis, 32% showed 50-99% stenosis and 38% of them showed total occlusions.

<table>
<thead>
<tr>
<th>PSV ratio</th>
<th>No. of patient</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2:1</td>
<td>12</td>
<td>24%</td>
</tr>
<tr>
<td>2 – 4:1</td>
<td>15</td>
<td>30%</td>
</tr>
<tr>
<td>&gt; 4</td>
<td>4</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Total block</strong></td>
<td><strong>19</strong></td>
<td><strong>38%</strong></td>
</tr>
</tbody>
</table>

Among the patients studied, 24% of them had PSV ratio <
2, 30% had in between 2 – 4 , 8% had > 4 and 38% showed total block.

In the study, haemodynamically significant stenosis ie. > 50% stenosis was mostly found in femoro popliteal segments followed by dorsalis pedis artery.

**Case No. – 1**
Proximal stenosis and distally occluded lt. sfa reformed by collaterals with low resistant flow in arteries of leg

*Thrombosed proximal lt. SFA*  
*Stenosis with increased PSV*

*Occluded distal SFA with mod. Echogenic thrombus*  
*Oclusion of SFA with collaterals*

*Low resistant flow in lt. PA*  
*Low resistant flow in lt. ATA*

**Case No. – 2**
Occluded Lt Politeal Artery Reformed By Collaterals With Low Resistant Monophasic Flow In Arteries Of Leg

*Normal Trihasic Flow In Lt Cfa*  
*Oclusion Of Lt Pop.a Reformed By Collaterals*

**Case No. – 3**
Occlusion Of Rt. Pa Reformed By Collaterals With Low Resistant Monophasic Flow In Arteries Of Leg

*Normal RT. SFA*  
*Thickened Intima Media With Low Echogenic Thrombus*

*Occluded Pa With Collaterals*  
*Low Resistant Flow In Rt. Ata*

**Case No. – 4**
Popliteal Artery Occlusion With Low Resistant Monophasic Flow Pattern In The Arteries Of Leg

*Normal Flow IN RT. CFA*  
*Normal Flow IN RT. PFA*

*Occluded Rt. Sfa With No Flow On Spectral Doppler*  
*Ocluded Rt. Pop Artery With No Flow*
Table No.–1: Symptom Wise Distribution Of Patients

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermittent claudication</td>
<td>21</td>
<td>9</td>
<td>30</td>
<td>60%</td>
</tr>
<tr>
<td>Rest pain</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>14%</td>
</tr>
<tr>
<td>Ulcer</td>
<td>8</td>
<td>4</td>
<td>12</td>
<td>24%</td>
</tr>
<tr>
<td>Gangrene</td>
<td>12</td>
<td>1</td>
<td>13</td>
<td>26%</td>
</tr>
<tr>
<td>Coldness</td>
<td>13</td>
<td>4</td>
<td>17</td>
<td>34%</td>
</tr>
<tr>
<td>Paresthesias</td>
<td>9</td>
<td>3</td>
<td>12</td>
<td>24%</td>
</tr>
<tr>
<td>Colour changes</td>
<td>15</td>
<td>6</td>
<td>21</td>
<td>42%</td>
</tr>
<tr>
<td>Impotence</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
</tr>
</tbody>
</table>

Table No. – 2: Risk Factors Wise Distribution

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>No. of patients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>25</td>
<td>50%</td>
</tr>
<tr>
<td>Smoking</td>
<td>24</td>
<td>48%</td>
</tr>
<tr>
<td>Alcohol</td>
<td>13</td>
<td>26%</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>23</td>
<td>46%</td>
</tr>
<tr>
<td>IHD</td>
<td>5</td>
<td>10%</td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>25</td>
<td>50%</td>
</tr>
</tbody>
</table>

Discussion:

Age distribution:

In our study 90% of the cases were above the age of 40 years and 10% of the cases were between the age of 15-40 years. It is well accepted fact that the lower extremity arterial disease was the disease of middle and older age groups as cited by Cossman et al.6

Sex distribution:

Among 50 diagnosed cases of peripheral vascular insufficiency, patients who underwent Doppler study 38 (76%) were males and 12 (24%) were females. Hughson et al7 observed that 2% of males and 1% of females had symptoms of peripheral vascular disease.

Signs and symptoms:

Intermittent claudication, rest pain and ulcer are very important signs of lower limb ischaemia. We found 60% of patients in this study having intermittent claudication. Tetsuo Ostida et al8 found 69 out of 144 ischemic limbs of TAO having this symptom. B. Ranjan9 reported 105 rest pain and 62 gangrene / ulceration of total 188 cases.

In our study 25% cases had gangrene and 22% cases had ulcers. B. Ranjan noted that the maximum gangrene was associated with distal blocks and popliteal blocks. The incidence of gangrene being 50% in each case, while with femoro-popliteal it was 20%. Our study showed that the maximum block at the level of femoro-popliteal trunk followed by distal run-off arteries. Other symptoms were colour changes (42%), coldness (34%) and Paresthesias (24%). In our study we found clinical evaluation of peripheral pulses as a very important adjunct to colour Doppler study. It helps to suspect the possible site of block and we found good correlation between clinical levels of block and colour doppler findings in majority of cases.

Risk factors:

In our study 48 % of the patients were smokers with average smoking of 25 - 30 cigarettes / beedis per day for a period ranging from 10 - 30 years. Tobacco smoking affects both arteriosclerosis obliterans and thromboangitis obliterans (TAO) but TAO is exclusively seen in young smokers. The relationship between smokers and PVD is known since 1911 when Erb10 reported intermittent claudication was 3 times more common among the smokers. 30% of patients in our study had history of alcohol intake for average of 10 years.

Plaque characterization and percentage of stenosis:

In our study we found atherosclerotic plaque was moderately echogenic in 41.3% of patients, strongly echogenic in 37.9% and low in echogenicity in 20.6% of patients. Among 50 patients studied with peripheral vascular insufficiency 29 (58%) patients had atherosclerotic plaque suggesting that significant number of patients had peripheral arterial disease. Out of 29 plaque patients 16 patients had significant stenosis i.e. 50 - 99% occlusion 15 patients had 1 - 49% stenosis. Out of 50 patients studied, 19
(38%) patients had complete occlusion.

Among the patients who had hemodynamically significant stenosis 75% had lesions at femoro-popliteal segment, 35% at iliac-segment and 40% at infrapopliteal segment. Our study is comparable to study by Ahchong K et al.11 In patients who had complete occlusion, collaterals were noted in significant number of cases but exact site of origin, number of collaterals and distal reformation site could not be demonstrated in all cases.

**PSV ratio:**

Among patients who had plaque 15 (30%) had PSV ratio of 2 - 4, 4(8%) had PSV ratio >4, 12 (24%) had <2 and 16 (40%) patients had total block. PSV at stenosis and ratio of PSV at stenosis is compared with velocity 1-2cm upstream in a non diseased segment.

According to Cossman et al6 PSV ratio of >2 are indicative of Hemodynamically significant stenosis i.e. >50%-75% stenosis and >4 have >75%- 99% of stenosis.

Cossman et al6 have produced accurate results by using PSV ratio for quantifying degree of stenosis. In our study PSV ratio was used which is easy to remember and it can also sub classify 75-99 % of stenosis.

**Spectral waveform changes:**

In our study spectral waveform changes were observed and the 2 main features, which are altered are, the overall shape of the waveform and the degree of spectral broadening as a result of flow disturbance.

The spectral waveform was monophasic i.e. loss of third and then second phase of the normal triphasic waveform at the areas of hemodynamically significant stenosis and distal to it. The width of the first, systolic complex is increased and overall height is decreased.

These changes result in dampening of the waveform which is most marked when there is proximal occlusion.

The turbulence generated beyond the stenosis resulted in spectral broadening and spectral fill-in under normal window under the first phase systolic peak. No flow was recorded in cases of occlusion.

In cases with distal disease the changes which were seen are the reduced diastolic component, evident from the loss of third component and reduced peak systolic velocity.

These findings are comparable to findings of other studies Jager KA et al.12 Other findings included diffuse irregularity of the vessel wall and resultant irregular colour fill-in in most of the patients suggesting increased Intima-medial thickness.

**Conclusion:**

Elderly people are with increased risk of peripheral arterial disease. Males are more commonly affected with smoking as the commonest risk factor. The other common risk factors include diabetes and hyperlipidemia. The commonest site of pathology is femoro-popliteal segment.

Duplex color Doppler sonography can accurately locate the site and extent of stenosis/occlusion.

Duplex sonography can be used to classify peripheral arterial disease into hemodynamically non-significant and significant using Peak systolic velocity, Peak systolic velocity ratios and spectral waveforms which will help in
Duplex Doppler imaging is safe, cost effective, repeatable, noninvasive procedure for investigating lower limb arteries. Hence it is the primary investigation of choice in all cases of lower extremity arterial disease and helps to decide the need for further evaluation by angiography.

Duplex sonography allows the evaluation and quantification of arterial disease.

Color Doppler study also helps in the follow-up of the arterial diseases.

References:


