Role of Pulse Oximetry and Ankle Brachial Index in Diagnosis of Lower Limb Artery Disease (LEAD) in Patients with Coronary Artery Disease

Anoop Jain1, Ganesh Seth2*, Sanjay Parmar3, Harikishan Srivastava4, Sarita5

Abstract

Background: Lower extremity arterial disease is common disorder affecting large number of peoples and is frequently asymptomatic. Currently ABI is used as screening test for LEAD, which is time consuming and requires special instrument for measurement. We compare the role of pulse oximetry, ABI and its combination in diagnosis of LEAD.

Methods: Total 224 patients (448 limbs) were enrolled in the study. Complete history, examination was done. Pulse oximetry of all limbs and ABI of both lower limbs were measured. CT angiography and pulse Doppler was done to diagnose LEAD.

Results: Pulse oximetry was found to have sensitivity of 60.5%, specificity of 95.9% positive likelihood ratio 14.93 and negative likelihood ratio 0.41. ABI was found to have sensitivity of 69.7%, specificity of 97.3%, positive likelihood ratio 25.8 and negative likelihood ratio 0.32. But when both are combined, sensitivity increases to 84.2%, specificity decreases to 91.9%, positive likelihood ratio decreases to 10.39 and negative likelihood ratio decreases to 0.17.

Conclusion: Our study suggests that pulse oximetry is simple and non-invasive test that provides quick result which is at least as accurate as ABI and thus is an easy alternative/ additional method for the screening of LEAD. However when used in combination with ABI the sensitivity for the detection of LEAD increases.

Introduction

Lower extremity artery disease is a common cardiovascular disease that is estimated to affect approximately 202 million individuals worldwide1 and increases with aging. LEAD is associated with significant morbidity, mortality, and quality of life impairment2. LEAD esp. when symptomatic is more prevalent in men in high-income countries but in low and middle-income countries it is more prevalent in women.1 Although the prevalence of critical limb ischemia is low (0.4%), the total number of individual having LEAD is increasing with a 23% increase in the prevalence in last decade as a result of total population increase, aging, increased incidence of diabetes and smoking worldwide.1 In India, Peripheral artery disease of the lower extremity is an important cause of morbidity and affects 10 million peoples.3 Atherosclerosis is the most common cause of LEAD worldwide; and since it is a generalized disorder and involves medium and large sized arteries. Many patients with symptomatic peripheral artery disease (PAD) have evidence of coronary artery disease (CAD) based on clinical presentation and electrocardiogram and coronary angiography. The high prevalence of combined CAD and PVD has been confirmed in two large international studies—the REACH (Reduction in Atherothrombosis for Continued Health) registry and the AGATHA (A Global Atherothrombosis Assessment) study in which 16 to 35% of patients (with established atherosclerotic disease or three or more risk factors) had polyvascular disease.4,5 The presence of combined lower extremity PVD and CAD is associated with nearly doubled all-cause mortality, to 4.6% per year, compared with either disease alone.4

The diagnosis of PAD begins with clinical suspicion in the typical patient population. Increased rates of PAD have been demonstrated in patients with coronary artery disease, cerebrovascular disease, diabetes, and renal failure.4,6 In 75% cases peripheral vascular disease is asymptomatic. In 25% cases peripheral vascular disease is symptomatic with intermittent claudication, coldness and numbness of feet, weakness of lower limb, dependent rubor, non-healing ulcer and gangrene. The most commonly ascribed symptom that develops as a result of PAD is intermittent claudication (IC). Most epidemiologic studies have used a noninvasive measurement, the ankle-brachial index (ABI), to diagnose PAD. The ABI is the ratio of ankle to brachial systolic blood pressure.

Pulse oximetry measures peripheral blood hemoglobin saturation of oxygen (SaO2). Pulse oximetry is a well-established method for non-invasive evaluation of arterial oxygenation. As the blood flow to the limb distal to stenosis decreases the limb develop coldness and numbness along with other ischemic changes like gangrene and ulcer because of hypoxia of limb. There are few studies that have shown that SaO2 measurement by pulse oximetry can detect LEAD.

1Senior Professor and Ex-HOD, Cardiology, SMS, Jaipur, Rajasthan; 2Associate Consultant, Interventional Cardiology, Medanta, Lucknow, Uttar Pradesh; 3Associate Consultant, Interventional Cardiology, Shri Balaji Action Medical Institute, New Delhi; 4Consultant Cardiologist, Popular Hospital, Varanasi, Uttar Pradesh; 5Resident, B.B.D.C.O.D.S., Lucknow, Uttar Pradesh; *Corresponding Author

Received: 05.10.2018; Accepted: 20.12.2019
My study aims at establishing the role of ABI and pulse oximetry in detection of LEAD.

Methods

This study is hospital based observational study. The patients with admitted to department of cardiology S.M.S. Medical College and hospitals were enrolled. Study duration was 12 months.

Exclusion criteria’s were patients with (1) Patients with renal failure, (2) digital necrosis/gangrene of all toes hampering Spo2 measurement, (3) cardiogenic shock or COPD having decreased saturation in all four limbs, (4) Absent pulsatile waveform in limb in Spo2 probe and (5) B/L upper limb PAD.

Oxygen saturation (SaO2) of index figure of upper limb and 2nd or third toe in lower limb was measured with the patients in the supine position and at 12-in elevation of the foot, using a pulse oximeter at room air. Before measurement patient advised to wash hands and feet and allowed to dry at room temperature and nail polish if applied was removed. ABI was calculated as ratio of ankle to brachial systolic blood pressure. Ankle pressure was measured by pneumatic cuff placed around the ankle is inflated to suprasystolic pressure and subsequently deflated while the onset of flow is detected with a Doppler ultrasound probe placed over the dorsalis pedis or posterior tibial arteries, thus denoting ankle systolic blood pressure.

Definitions

Abnormal pulse oximetry was defined as a SaO2 value of more than 2% lower in the toes than finger value in supine or a decrease of more than 2% on 12-inch elevation of the leg (decrease from the value at the supine position). An abnormal ABI was defined as less than 0.9. For the combination of ABI and pulse oximetry, we defined a positive test result as either an ABI of less than 0.9 or a decrease in SaO2 of more than 2%, as described herein; a negative test result for the combination was an ABI of 0.9 or more and an SaO2 decrease of 2% or less. Significant LEAD was defined as the presence of monophasic waveforms at any one of the lower extremity arteries during Doppler waveform analysis and/or more than 50% stenosis of aortoiliac or CFA disease on CTA.

Statistical analysis

Sensitivity, specificity, and likelihood ratios were derived for abnormal pulse oximetry and ABI results to detect LEAD and for the combination of the two were calculated.

Results

We enrolled total 224 patients (448 limbs) in the study. Detailed history and examination was performed. Patient characteristics are given in Table 1. Mean age of patients was 54.4±12.3 years. Most of the patients, 206 (92%) were smoker and male 197 (88%). Out of 56 patients 36 patients were diabetic, 64 were hypertensive.

We found that significant LEAD was found in 152 limbs (34%) on the basis of CTA and Doppler examination. Pulse oximetry and ABI data is given in Table 2.

As indicated in the tables, the ABI test had better test characteristics but with 95% CIs that overlapped with the pulse oximetry test results.

Pulse oximetry has a Sensitivity of 60.5% (95% CI; 52.2-68.3%), Specificity of 95.9% (95% CI; 93-98%), and Positive likelihood ratio 14.93 (95% CI; 8.45-26.3%) and Negative likelihood ratio 0.41 (95% CI; 0.34-0.5%). ABI has a Sensitivity of 97.3% (95% CI; 94.7-99%), Specificity of 97.3% (95% CI; 94.7-99%), and Positive likelihood ratio 25.8 (95% CI; 12.9-51.5) and Negative likelihood ratio 0.32 (95% CI; 0.12-0.40%).

So, in our study, ABI was found more sensitive than pulse oximetry in the detection of LEAD. However when the both tests are used in combination, Sensitivity increases to 84.2% (95% CI; 77.4-89.6%), Specificity decreases to 91.9% (95% CI; 88.2-94.8%), and Positive likelihood ratio 10.32 (95% CI; 7-15.33%).

Table 1: Demographic profile of enrolled patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total patients/limbs</td>
<td>224/448</td>
</tr>
<tr>
<td>Age (mean±SD) in years</td>
<td>54.4±12.3</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>192/32</td>
</tr>
<tr>
<td>Smoking</td>
<td>204 (91%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>64 (32%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>36 (16%)</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>12 (5%)</td>
</tr>
</tbody>
</table>

Table 2: Results of pulse oximetry, ABI and combination

<table>
<thead>
<tr>
<th></th>
<th>LEAD present</th>
<th>LEAD absent</th>
<th>Sensitivity (95%CI); %</th>
<th>Specificity (95%CI); %</th>
<th>Positive LR (95%CI); %</th>
<th>Negative LR (95%CI); %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse oximetry</td>
<td>Positive</td>
<td>92 (61)</td>
<td>12 (4)</td>
<td>60.53</td>
<td>95.95</td>
<td>14.93</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>60 (39)</td>
<td>284 (96)</td>
<td>(52.2-68.3)</td>
<td>(93-98)</td>
<td>(8.45-26.3)</td>
</tr>
<tr>
<td>ABI</td>
<td>&lt;0.9</td>
<td>104 (69)</td>
<td>8 (3)</td>
<td>67.9</td>
<td>97.3</td>
<td>25.8</td>
</tr>
<tr>
<td></td>
<td>&gt;0.9</td>
<td>48 (31)</td>
<td>288 (97)</td>
<td>(61.7-76.9)</td>
<td>(94.7-99)</td>
<td>(12.9-51.5)</td>
</tr>
<tr>
<td>Combination</td>
<td>Positive</td>
<td>128 (84)</td>
<td>24 (8)</td>
<td>84.21</td>
<td>91.9</td>
<td>10.39</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>24 (16)</td>
<td>272 (92)</td>
<td>(77.4-89.6)</td>
<td>(88.2-94.8)</td>
<td>(7.0-15.33)</td>
</tr>
</tbody>
</table>

Fig. 1: Comparison of sensitivity and specificity of pulse oximetry, ABI and their combination in patients with LEAD

- Sensitivity
- Specificity

Figure 1: Comparison of sensitivity and specificity of pulse oximetry, ABI and their combination in patients with LEAD.
and Negative likelihood ratio 0.17 (95%CI; 0.12-0.25%).

Our study suggests that although inferior to ABI, pulse oximetry also has the sensitivity of 60% and specificity of 95% for detection of LEAD and when used in combination with ABI sensitivity increases and there was more chances of accurately identifying the patients with LEAD.

Discussion

In our study, we found that difference in the oxygen saturation between fingers and toes assessed by pulse oximetry in the supine or 12-inch elevation of lower limb is at least as accurate as ABI in detection of lower limb arterial disease. However the combination of both has better sensitivity than when used alone.

LEAD is a risk factor for increased total mortality, morbidity and QOL impairment.10 This risk seems to persist even when LEAD is subclinical.9 Early detection of LEAD can lead to better control of risk factors for cardiovascular events and better outcomes,11 that is why screening should be done in high-risk population to detect the disease even when it is asymptomatic or subclinical to improve the future outcomes. However awareness of LEAD, its significance and screening for LEAD is low among the primary care physicians.12

Currently recommended screening tests include pulse palpation and the ABI.13 Although palpation of pulse is quite easy to perform but it also has high interobserver variability. The negative predictive value of a posterior tibial pulse is 96%, but the positive predictive value is only 49%.14 Moreover dorsalis pedis artery can be congenitally absent in 4% to 12% of the population.15 The ABI has been reported to be very sensitive and specific in patients suspected of having arterial disease,16 but others report that the ABI is not a sensitive test in patients with renal failure, diabetes mellitus and thickened arteries.17 And, ABI also require specialized Doppler device for accurate measurement.

Pulse oximeters measure peripheral blood hemoglobin SaO2. Low blood flow in an extremity produces lower SaO2 in the blood, a fact that vascular surgeons use to assess patency of arterial reconstructions.18 Previous investigations of pulse oximetry to diagnose LEAD have produced mixed results. Joyce et al19 compared the ABI, pulse oximetry measurement of the toes, and transcutaneous oxygen tension measurement with the arteriographic appearance in patients suspected of having limb ischemia. They found that pulse oximetry correlated best with the arteriographic appearance.

Parameswaran et al. studied the pulse oximetry in asymptomatic patients with diabetes mellitus and concluded that pulse oximetry is as accurate as ABI to screen asymptomatic LAD patients with diabetes.20 Jawahar et al. compared the pulse oximetry in asymptomatic LEAD and normal individuals and had negative results and concluded that oximetry is not very sensitive test for symptomatic LEAD.21

Our study suggests that pulse oximetry is at least as accurate as ABI and is an effective additional method for the screening of LEAD. However when used in combination with ABI the sensitivity for the detection of LEAD increases. Pulse oximeters are widely available in patient care areas and easy to use. The technique of measuring SaO2 is well known, simple, noninvasive, and inexpensive tool, which gives quick result and thus makes it a good screening tool.

The limitations of this study are as follows: (1) the small number of patients; (2) performance of the tests on a specific patient population group and study population does not represent general population overall so results may not be generalized.

In conclusion, these results suggest that pulse oximetry may be a useful additional tool to screen for LEAD in high-risk patients. It has a sensitivity and specificity nearly similar to the ABI. Larger studies are needed to confirm how it compares with the ABI. When combined with the ABI, the results for the combination of the two tests are superior to the ABI or pulse oximetry alone in detecting LEAD in these patients.

References