ORIGINAL ARTICLE

Determination of Peripheral Artery Disease using Ankle-Brachial Index

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Abstract

Aim: The main aim of this study is to determine peripheral artery disease (PAD) using ankle-brachial index (ABI) who is having the risk factors for developing PAD and also determine additional risk factors which are responsible for vascular risk leading to PAD in future and to assess the patients who are at high risk for developing complications such as stroke and coronary artery disease (CAD). **Materials and Methods:** A total number of 500 patients who met the study criteria were included in the study. The required data were collected by measuring ankle, brachial pressures for the patients and some data related to the patients were collected through patient's case sheets and medical records. The collected data were analyzed statistically. **Results and Discussion:** It was observed that smoking is the major contributing risk factor for PAD. Diabetes is the second most contributing risk factor for PAD, followed by CAD, obesity, hypertension, dyslipidemia, and alcohol. The risk for PAD was observed to be more in males compared to females. PAD patients have remained asymptomatic even at severe risk. Moreover, the majority of the patients are at moderate risk for PAD. The patients with age group of 51–60 years were at a higher risk for PAD and testing the people with ABI of age above 50 years having PAD risk factors might be beneficial. **Conclusion:** Finally, the use of ABI as a screening test in all primary health-care settings could be useful to detect the risk for PAD at an early stage and can prevent further complications.

Key words: Ankle-brachial index, coronary artery disease, diabetes, dyslipidemia, peripheral artery disease

INTRODUCTION

Peripheral artery disease (PAD) is narrowing or occlusion of the lower extremity arteries primarily due to atherosclerosis.[1] However, peripheral arterial disease can also be defined as atherosclerosis of the distal aorta and/or lower limb arteries causing arterial narrowing and disruption of blood flow to the legs. PAD is a common condition that is underdiagnosed and is associated with a 2–3 fold increase in cardiovascular mortality.[2,3] More severe forms of peripheral arterial disease present as rest pain, gangrene or ulceration, and occasionally leading to amputation.[4]

ABI

ABI is a non-invasive vascular screening test to identify the large vessel, peripheral arterial disease by comparing systolic blood pressures in the ankle to higher of the brachial systolic blood pressures, which is the best estimate of central systolic blood pressure.[5,6]

The purpose of the ABI is to support the diagnosis of vascular disease by providing an objective indicator of arterial perfusion to a lower extremity.[7] ABI is a ratio obtained from dividing the higher of the ankle pressures (i.e., dorsalis pedis and posterior tibial) for each leg by the higher of the right and left arm's brachial systolic pressures. If blood flow is normal in the lower extremities, the pressure at the ankle should be equal or slightly higher than that in the arm with a value of 1.0 or more and ABI <0.9 indicates lower extremity arterial

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disease.[8,9] ABI has a sensitivity of >90% and a specificity of >95% in diagnosing 50% stenosis of the lower extremity arteries.[10,11]

Aim

The aim of the study was to determine the PAD using ABI in patients who are having the risk factors for PAD.

Objectives

The objectives are as follows:

- To assess the vascular risk to predict the peripheral arterial disease in asymptomatic patients.
- To determine additional risk factors which are responsible for vascular risk which lead to PAD in future.
- To assess the patients who are at high risk of developing complications such as stroke and coronary artery disease (CAD).
- To estimate the proportion of patients falling under different classes of vascular risk.
- To assess the gender wise distribution of vascular risk.
- To assess body mass index (BMI) wise distribution of vascular risk.

MATERIALS AND METHODS

Study design

It is a prospective observational study.

Study site

The study was conducted at Yashoda Hospitals, Secunderabad, Telangana, India.

Study period

The study was conducted for 6 months.

Study population

A total of 500 patients who are having the necessary risk factors were included in the study.

Study criteria

Inclusion criteria

- Patients both male and female, above 30 years taking prophylactic anticoagulant therapy are to be included.
- Patients exposed to at least one or more of the risk factors are to be included.
- Patients who are admitted in the hospital for the treatment of heart diseases such as myocardial infarction and CAD were included in the study.

Exclusion criteria

- Patients both male and female below 30 years of age.
- Amputation patients, patients, undergone any kind of knee surgery.
- Pregnant, lactating women, and pediatric patients.
- Patients who are not willing to participate in this study.
- Patients suffering with deep vein thrombosis, leg ulcers, gangrene, and filariasis.
- Patients with lower limb swelling with any other causes.

Methodology

- A field study was performed on the patients who are suffering with risk factors.
- A data collection form was designed to collect patient data including demographics, medication history, laboratory and investigational data, therapeutic management, and procedures.
- All the details of the study population included in the study were collected as per the designed data form.

ABI

ABI is a non-invasive vascular screening test used to identify the large vessel, peripheral arterial disease by comparing systolic blood pressures in the ankle to higher of the brachial systolic blood pressures, which is the best estimate of central systolic blood pressure. ABI is a ratio obtained from dividing the higher of the ankle pressures (i.e., dorsalis pedis and posterior tibial) for each leg by the higher of the right and left arm's brachial systolic pressures. It takes about 5–8 min to perform the test which depends on the condition of the patient. The procedure involves.

Measuring the brachial pressures

The patient should be in the supine position. Place the blood pressure cuff on the arm, with the limb at the level of the heart. Place a drop of ultrasonographic gel on the brachial artery and place the Doppler probe at 45 angles on the gel. Rapidly inflate the cuff to 180 mmHg. Release air from the cuff at a moderate rate (3 mm/s). Listen to the sounds from the Doppler and simultaneously observe the sphygmomanometer. The first shooting sound from the Doppler is the subject's brachial systolic pressure. Repeat the same procedure on the other arm. The higher of the two brachial values is to be taken.

Measuring the ankle pressures

Place the cuff immediately proximal to the malleoli. Place a drop of ultrasonographic gel on the dorsalis pedis artery and place the Doppler probe at 45 angles on the gel rapidly inflate the cuff to 180 mmHg. Release air from the cuff at a moderate rate (3 mm/s). Listen to the sounds from the Doppler and simultaneously observe the sphygmomanometer. The shooting sound from the Doppler is the subject's ankle systolic pressure. Repeat the same procedure on the posterior tibial artery. Repeat the same procedure on the opposite leg. ABI must be calculated for both the legs taking into account only the higher brachial systolic pressure.

Formula:

$$\text{ABI} = \frac{\text{Highest systolic blood pressure at the ankle}}{\text{Highest brachial pressure of the arm}}$$

Patients with mild-to-moderate PAD are likely to experience lower extremity pain with exercise (claudication) whereas patients with ABI ≤0.4 are likely to have lower extremity pain while resting. ABI < 0.4 increases the risk of limb loss, gangrene, ulceration, and delayed wound healing. An abnormal ABI establishes the diagnosis of PAD, and in many cases, no additional diagnostic testing is necessary [Table 1].

RESULTS

This pie chart shows the gender representation of the population in which 59.4% were male and 40.6% were female. Comparatively, the majority of male patients was included in the study of random selection [Figure 1].

This graph illustrates that the majority of patients of both the genders were observed at the age group of 51–60 years followed by the age group 61–70. Out of 500 patients, 310 patients were observed under risk of PAD [Figure 2].

A total of 310 patients were observed under risk of which 57% were males and 43% were females. Comparatively, the majority of the risk is observed in male patients to that of females [Figure 3].

The study found that 310 patients are under abnormal ABI results of which majority of the patients of both the genders were observed at the age group of 51–60 followed by the age group 41–50 in which majority of the mild, borderline, and severe categories were found in the age group of 51–60 and

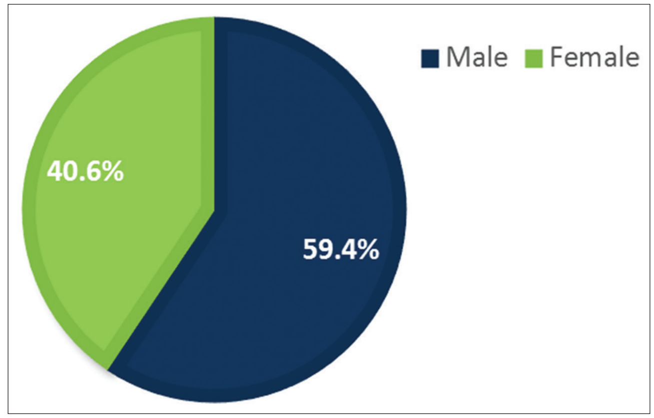

Figure 1: Gender-wise population

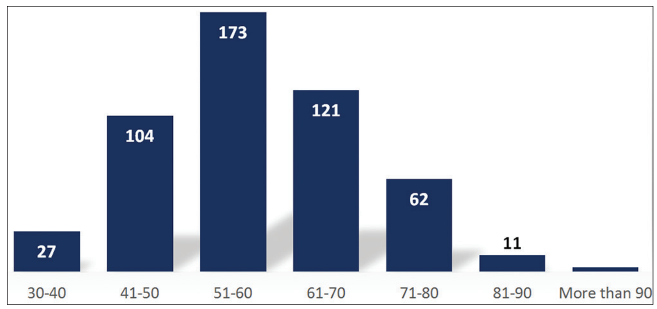

Figure 2: Age-wise distribution of the study population

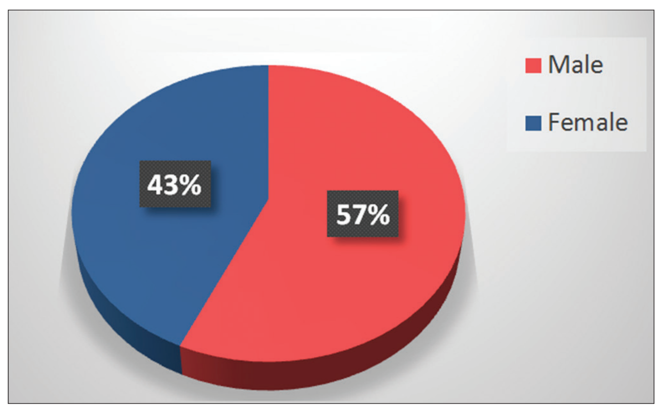

Figure 3: Gender-wise distribution of ankle-brachial index risk [Figure 3]

Table 1: ABI reference scale

ABI value	Interpretation	Recommendation
>1.4	Calcification or vessel hardening	Refer to vascular specialist
1.0–1.4	Normal	None
0.9–1.0	Borderline	None
0.7–0.9	Mild arterial disease	Treat risk factors
0.4–0.7	Moderate arterial disease	Refer to vascular specialist
<0.4	Severe arterial disease	Refer to vascular specialist

ABI: Ankle-brachial index

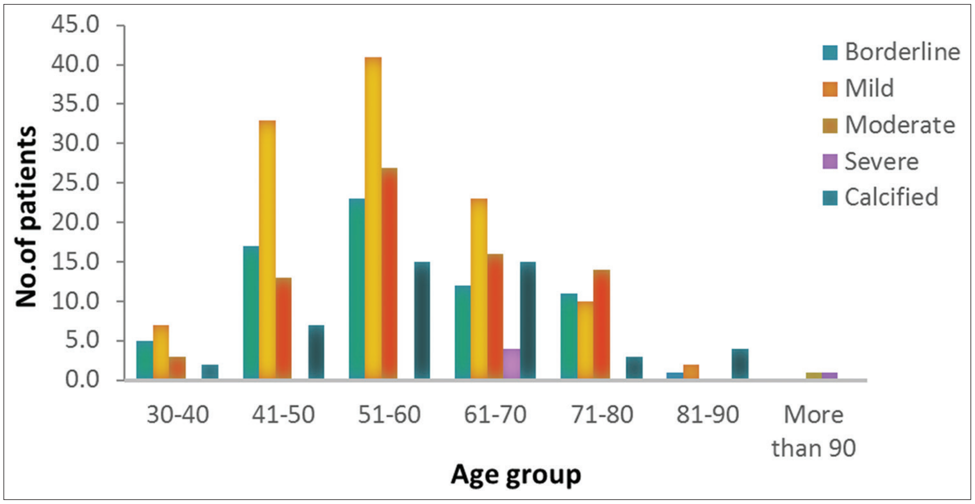

Figure 4: Age-wise distribution that was under vascular risk

most of the severe and calcified were observed in the age group of 61–70 [Figure 4].

This pie chart depicts about stage-wise ABI distribution of which majority of patients were observed in mild (37%), followed by moderate (24%), borderline (22%), calcification (15%), and finally severe of 2% of the population [Figure 5].

This graph represents that majority of the patients included in the study were normally followed by overweight, obese Class 1, obese Class 2, underweight, obese Class 3, severely underweight, and finally very severely underweight [Figure 6].

This chart illustrates that majority of mild patients were found in the category of overweight [Figure 7].

This graph shows that post-menopausal women are more prone to mild, borderline, calcified, and severe, whereas both premenopausal women and postmenopausal women share equal moderate risk for PAD [Figure 8].

This graph represents that regular smokers are at moderate risk of peripheral artery disease [Figure 9].

This graph depicts that regular alcoholics are more prone to moderate risk followed by mild and calcification whereas occasional alcoholics are more prone to the borderline risk of PAD [Figure 10].

This graph illustrates that patients with 141–160 cm of height have high risk for PAD followed by 161–180 cm patients. This clearly tells us that decrease in height tends to increase the risk of PAD [Figure 11].

This graph depicts that most of the hypertensive patients were mild followed by moderate, borderline, calcification, and finally severe [Figure 12].

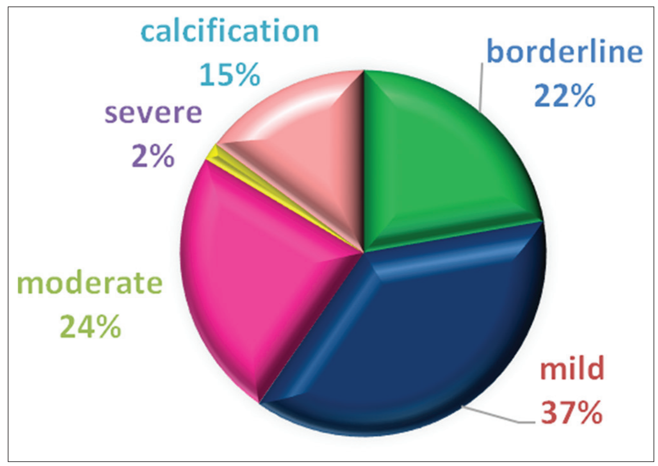

Figure 5: Ankle-brachial index stage- wise distribution of patients who are under risk

This graph depicts the patients who are suffering with diabetes; males are high in moderate followed by mild, calcification, borderline, and severe whereas females are high in the class of mild, followed by moderate, borderline, calcified, and severe [Figure 13].

This chart shows that 44% of dyslipidemia patients are falling under mild, followed by 24% of borderline risk, 20% of moderate risk for PAD, and calcification accounts for 12% of the patients [Figure 14].

This chart shows that most of the patients are under Stage 3 chronic kidney disease (CKD), followed by Stage 4, Stage 5, Stage 2, and finally Stage 1 [Figure 15].

This chart depicts that most of the CAD population are with single vessel disease and rest of the population are equally suffering with double vessel and triple vessel disease [Figures 16 and 17].

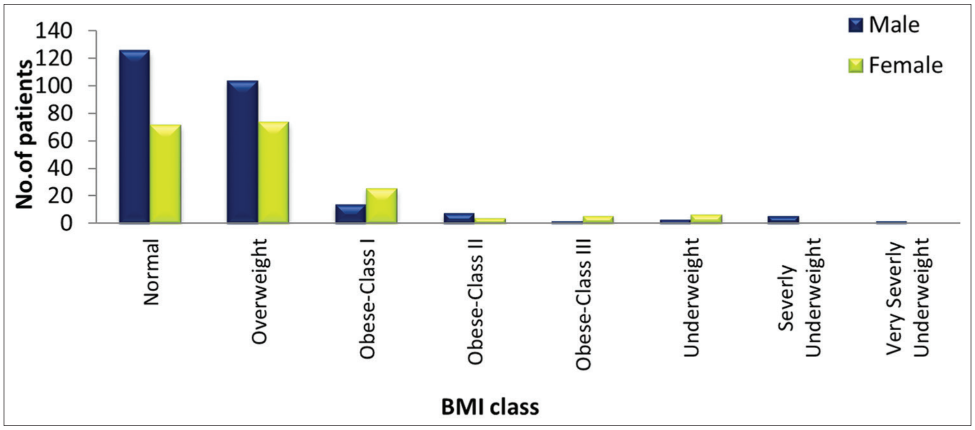

Figure 6: Ankle-brachial index stage-wise distribution of patients who are under risk[12,13]

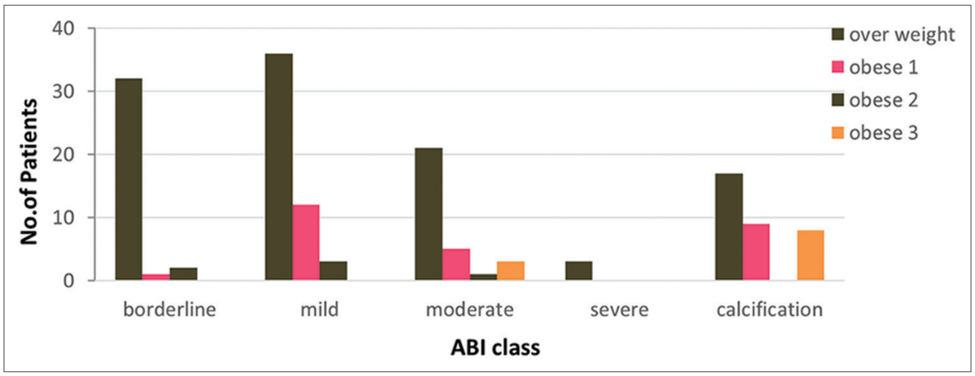

Figure 7: Representation of body mass index versus ankle-brachial index [Table 3]

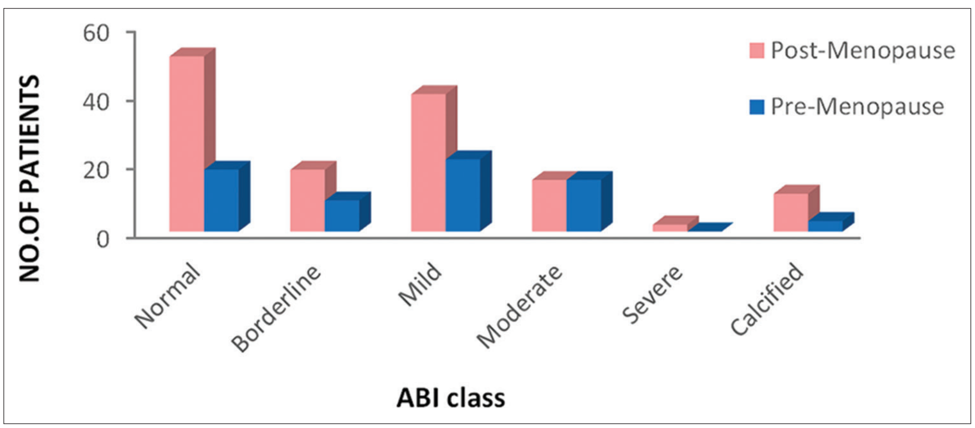

Figure 8: Menopausal status of women with abnormal ankle-brachial index

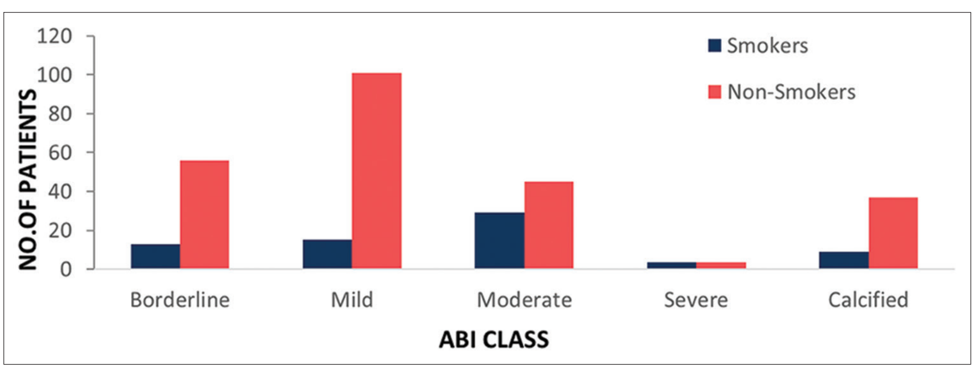

Figure 9: Patients with smoking and combination of other risk factors

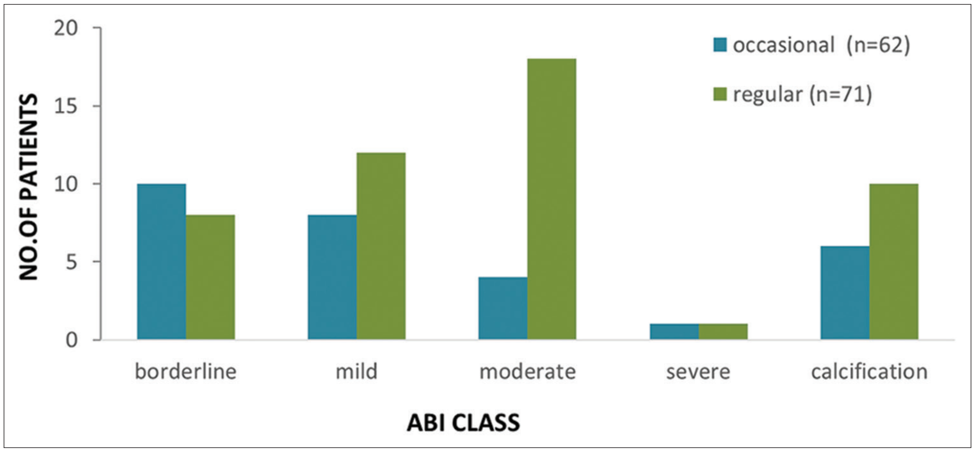

Figure 10: Peripheral artery disease risk in alcoholics

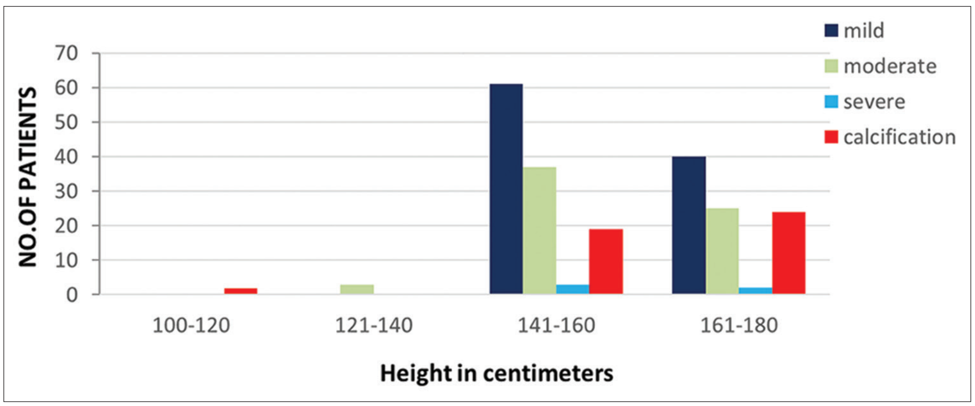

Figure 11: Patients according to height versus ankle-brachial index

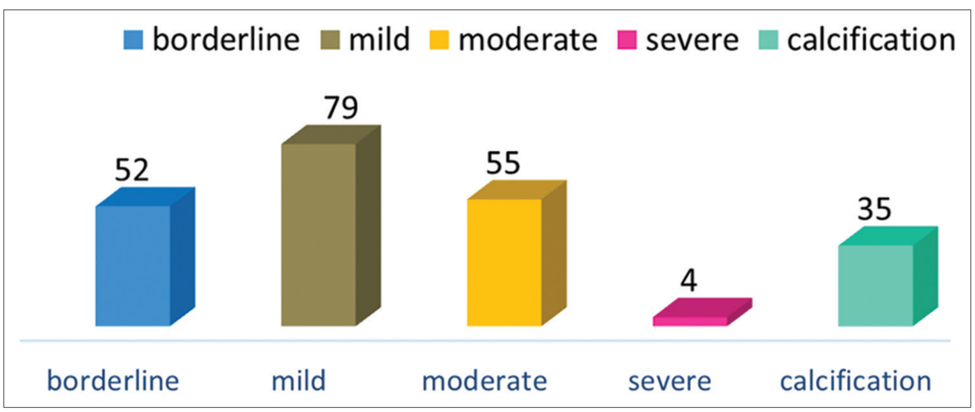

Figure 12: Ankle-brachial index abnormality in hypertensive patients

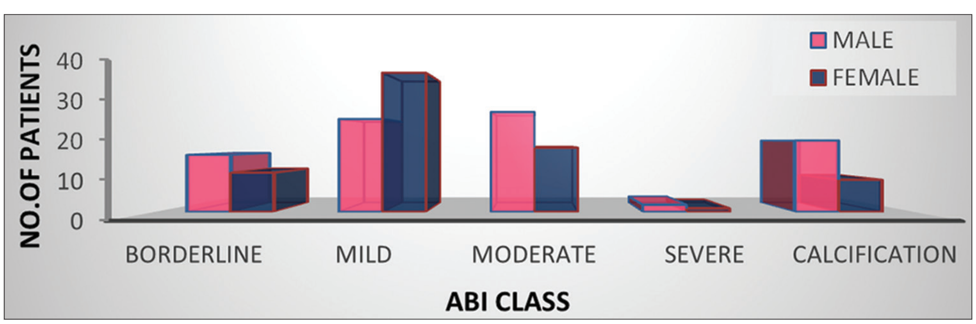

Figure 13: Peripheral artery disease risk in diabetes mellitus patient's gender wise

This graph illustrates that most of CAD patients were mild and equally effected in moderate and borderline followed by calcification [Figure 18].

This graph says that most of the hypothyroid patients are falling under mild risk, followed by moderate, equally affected with borderline, and calcification [Figure 19].

This graph shows that there is an only slight deviation between left and right ABI [Figure 20].

This graph depicts that most of the high hemoglobin A1c level patients are falling under moderate risk, followed by mild, borderline, calcification, and finally severe [Figure 21].

This graph shows that high levels of erythrocyte sedimentation rate patients are falling under mild risk, followed by moderate, borderline, calcification, and finally severe [Figure 22].

This chart illustrates that increased levels of high C-reactive protein in patients resulted with the vascular risk of 42% were mild, followed by borderline, moderate, and calcified [Figure 23].

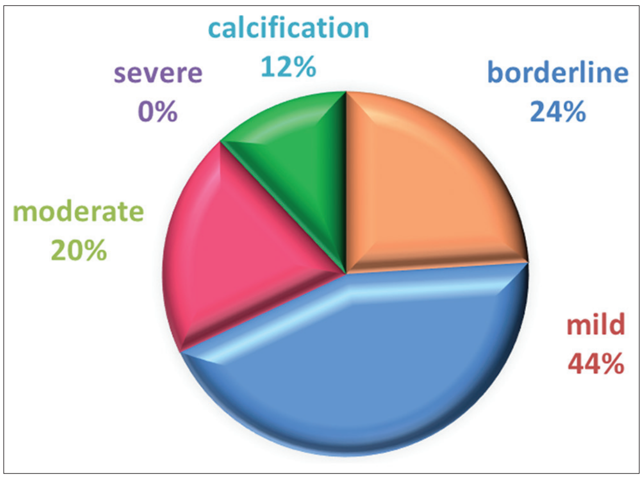

Figure 14: Peripheral artery disease risk in dyslipidemia patients

Table 2: Gender-wise distribution based on ABI risk

Gender	Number (percentage)
Male	176 (56.77)
Female	134 (43.22)

ABI: Ankle-brachial index

Table 3: Postmenopausal women with abnormal ABI

Number of patient	Postmenopause (*n*=137)	Premenopause (*n*=66)
Normal	51	18
Borderline	18	9
Mild	40	21
Moderate	15	15
Severe	2	0
Calcified	11	3

ABI: Ankle-brachial index

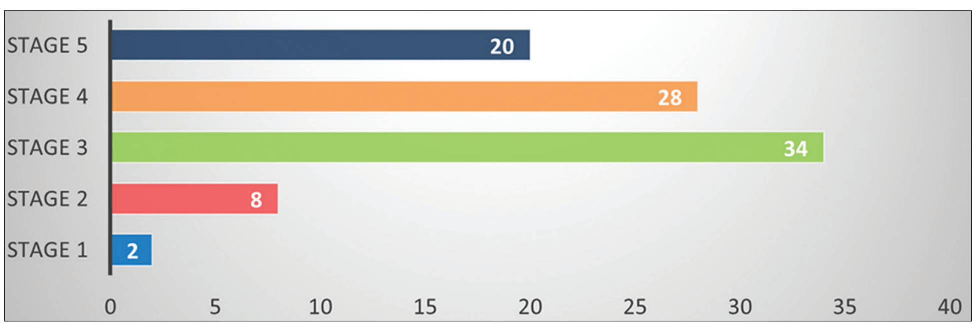

Figure 15: Patient distribution of chronic kidney disease with respect to stages

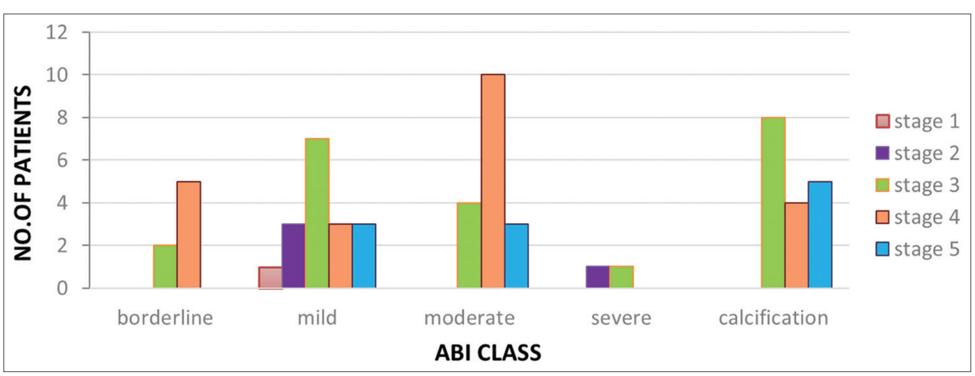

Figure 16: Peripheral artery disease risk in chronic kidney disease patients

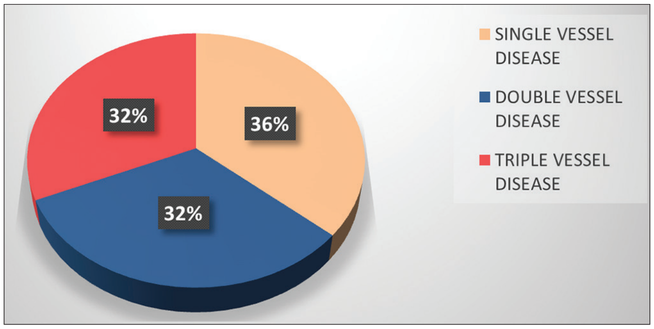

Figure 17: Chronic kidney disease (CAD) patients on the basis of type of CAD

This graph represents patients with high albumin are falling under mild, followed by moderate, calcification, borderline, and severe [Figure 24].

DISCUSSION

The study population comprises 500 patients who were having the triggering risk factors which are responsible for causing PAD. The study population was enrolled into the study on the basis of inclusion and exclusion criteria randomly. Out of 500 patients, 59.4% were male and 40.6% were female

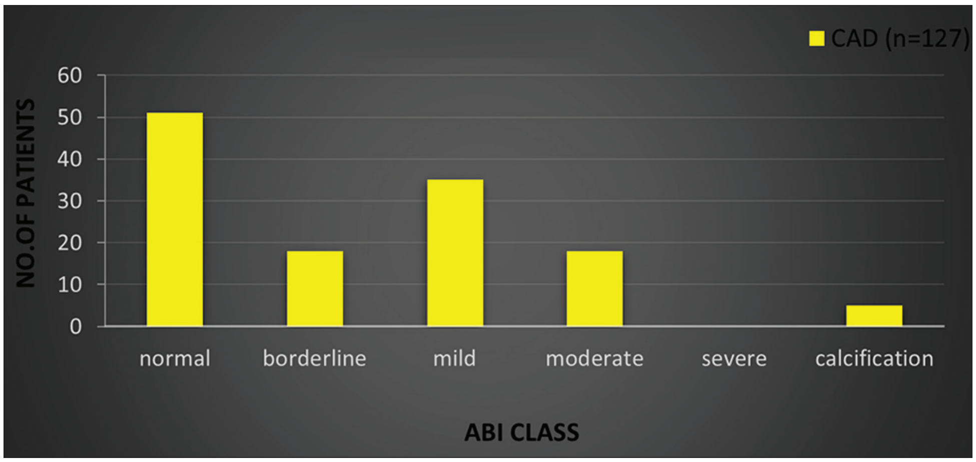

Figure 18: Chronic kidney disease population in relation to ankle-brachial index

Figure 19: Hypothyroid patients in relation to ankle-brachial index

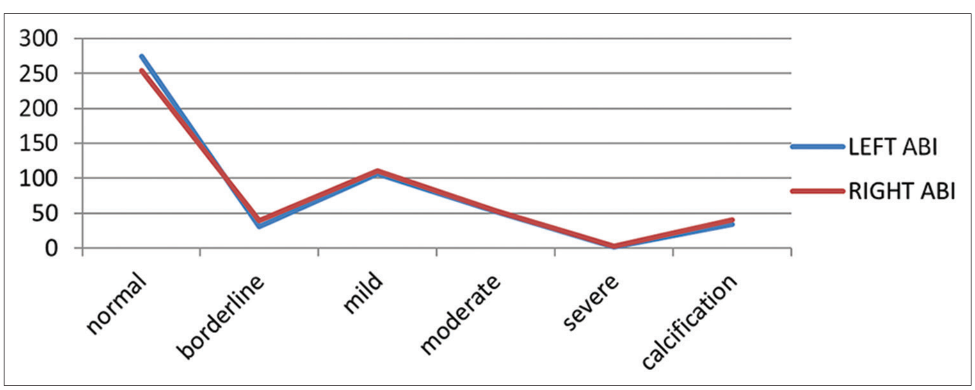

Figure 20: Ankle-brachial index risk with relation to ejection fraction

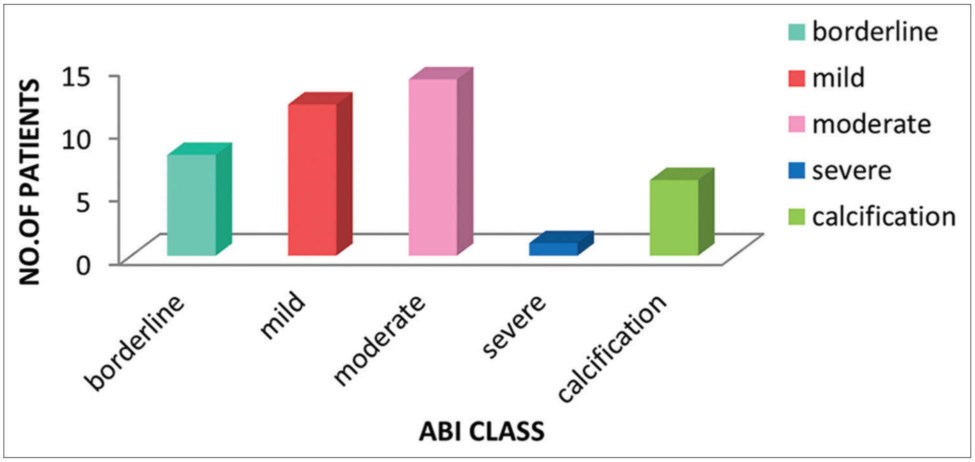

Figure 21: High hemoglobin A1c levels in relation to ankle-brachial index

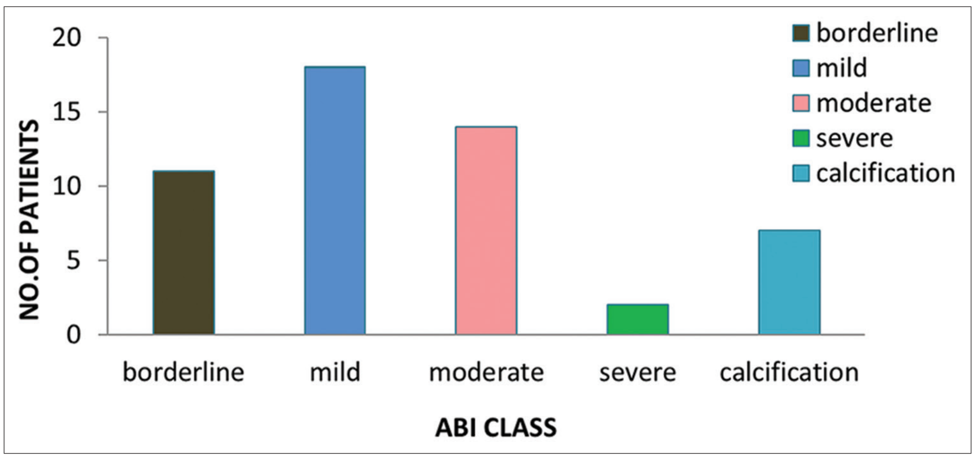

Figure 22: Elevated erythrocyte sedimentation rate in relation with ankle-brachial index

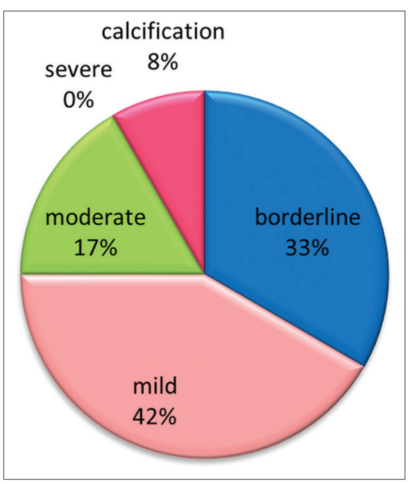

Figure 23: Patients with high C-reactive protein distribution based on ankle-brachial index abnormality

patients. In this random enrolment, males were higher when compared to females. ABI was performed to all these patients to assess the vascular risk which can determine the risk of PAD and predict the future vascular-related events in these patients. The risk factors for PAD include older age, obesity/sedentary lifestyle, stress, estrogen deficiency, smoking, alcohol, and diseases such as hypertension, diabetes mellitus, dyslipidemia, heart disease, kidney disease, and other inflammatory markers such as high levels of homocysteine and C-reactive protein.

ABI will divide the patient into different classes based on the vascular risk. The classes include borderline, mild, moderate, severe, and calcification (where the blood vessels of a patient become calcified and become incompressible to measure the blood pressure). On interpreting ankle-brachial results for these 500 patients, abnormal ABI results were observed in 62% (comprises all the above stages mentioned) of the patients whereas normal ABI is found in 38% of the study population. Among these abnormal ABI patients, 56.7% hold to be males 43.2% were females. Therefore, it is a clear indication that men were more prone to vascular risk than women. The reason for this might be several lifestyle factors that differ in men and women. Smoking has been the paramount risk factor for PAD and men are more prone to the habit of smoking than women, especially in a country like India. This might be one of the reasons that why the study showed high percentage of men with ABI risk. Other factors constitute to risk in men such as stress, improper diet, lack of proper physical activity, and sedentary lifestyle.

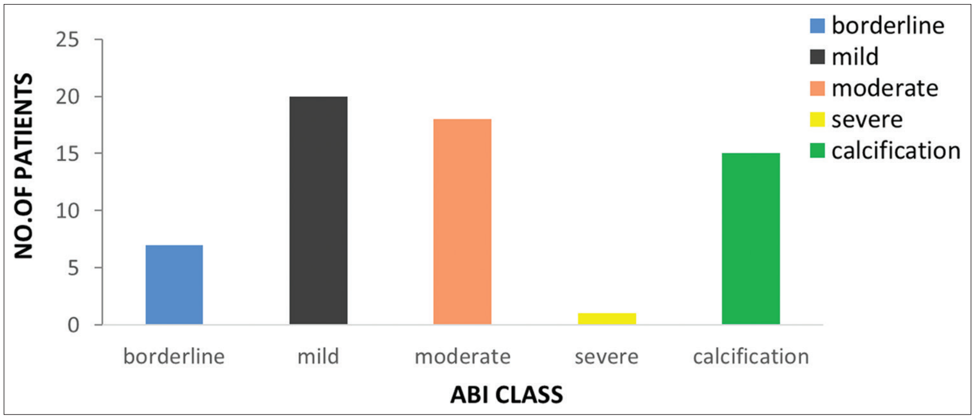

Figure 24: Albumin in relation with ankle-brachial index

Age group wise 100% abnormal ABI risk was observed in the age >90, followed by 41–50 risk of 67.3%, 81–90 risks of 63.6%, 30–40 risk of 62.9%, 71–80 risk of 61.2%, 51–60 risk of 61.1%, and finally age 61–70 with a risk of 57.8%. This can provide us information that the increase in age also increases the risk of PAD with complimenting risk factors which will naturally increase the risk to four- to five-fold. Particularly, PAD risk was observed in 39% of the total population which includes only mild, moderate, and severe. Among all the abnormal stages, patients are more in mild, i.e., 37.4% when compared to other stages. Patients who fall under borderline risk comprised 22.3%, moderate 23.4%, severe 1.6%, and calcification were found in 14.8% of the patients, respectively.

Our study found that smoking as the second most contributing risk factor to cause PAD with resulting abnormality of 66% among all the smokers. This prevalence increases as long-term smoking are associated with other diseases which can also cause PAD. Studies say that smoking cessation can decrease the vascular risk by 50% in patients. Our study depicts that Stage 1 CKD patients are under mild risk, Stage 2 patients are also in mild risk followed by moderate and severe whereas Stage 3 patients are more in calcification, followed by mild, moderate, borderline, and severe, and Stage 4 patients are more in moderate, followed by borderline, calcification, and mild. End-stage renal disease patients are more in calcification followed by moderate and mild. This clearly indicates that the vascular risk increases in the patient as the CKD stage progresses. Therefore, care has to be taken to halt further complications such as vascular events in the early stages of CKD its self. Diabetes is the most common complication found in almost all the patients which is the primary risk factor responsible to cause PAD. Uncontrolled diabetes can lead to kidney failure, heart failure, etc. These complications also tend to cause PAD. In our study, we found that 61.3% of diabetic patients were having vascular risk. Hence, controlling diabetes by any method can prevent patient's health condition.

Our study showed that 58.6% of alcoholic patients had vascular risk and can have vascular risk in future. Hence, it is mandatory for the patients to stop alcohol intake by slowly reducing its quantity which can prevent PAD and also many complications such as liver failure. It can also cause PAD by increasing serum cholesterol. Our study found that 54.6% of patients are having risk of PAD. Therefore, proper maintenance of thyroid function by following strict medication adherence can help patients in preventing from PAD. In our study, we have found that out of 500 patients, 69 patients were diagnosed with borderline risk, 116 patients were under mild risk, 74 patients were with moderate risk, and 5 patients were under severe risk. More priority should be given to moderate and severe class of patients who constitute about 25.5% which is 1/4th of the abnormal population who are asymptomatic with underlying disease, for whom necessary care has to be taken immediately and consider them as PAD patients and start them with the initial treatment of anti-coagulants and anti-platelets to prevent them from the complications of PAD such as ulcers, gangrene, and amputation.

Thus, our study confirms that PAD is underdiagnosed and remains asymptomatic in patients. Our study highlights that ABI is a very powerful screening test which can definitely diagnose the patients with vascular risk. We also believe that ABI should be used in all the primary health-care settings as a screening test which should be recommended for all the geriatric patients, chronic alcoholics, and regular, long-term smokers and also patients who possess specific risk factors which are mentioned above to diagnose PAD and help the patients in preventing the complications and also improving their quality of life.

CONCLUSION

The present study has been focused on determining the risk for PAD using ABI in patients who are having the risk factors which can cause PAD. It was observed that smoking is the major contributing risk factor for PAD. Diabetes is the second most contributing risk factor after smoking. CAD is the third risk factor later, followed by obesity, CKD, hypertension, dyslipidemia, and alcohol contributing for PAD. The risk of PAD was observed to be more in males when compared to females. The risk was more in patients with overweight when compared to other categories of BMI.

In our study, we have observed that PAD patients remained asymptomatic even at severe risk. Moreover, the majority of the patients are at moderate risk for PAD. We have also obsered that the patients with age group 51–60 years were at a higher risk for PAD and testing the people with ABI of age above 50 years having PAD risk factors might be beneficial. Hence, the use of ABI as a screening test in all primary health-care settings could be useful to detect the risk for at an early stage and prevent further complications.

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REFERENCES

1. Mohler E 3rd. Peripheral arterial disease. Arch Intern Med 2003;163:2306.
2. Olin JW, Sealove BA. Peripheral artery disease: Current insight into the disease and its diagnosis and management. Mayo Clin Proc 2010;85:678-92.
3. Aboyans V, Criqui MH, Abraham P, Allison MA, Creager MA, Diehm C, *et al.* Measurement and interpretation of the ankle-brachial index: A scientific statement from the American heart association. Circulation 2012;126:2890-909.
4. WOCN Clinical Practice Wound Subcommittee, 2005; WOCN Wound Committee, 2010-2011. Ankle brachial index. J Wound Ostomy Continence Nurs 2012;39:S21-9.
5. Omarjee L. Ankle-brachial index for diagnosing peripheral arterial disease. Radiographics 2017;37:362-3.
6. Khan TH, Farooqui FA, Niazi K. Critical review of the ankle brachial index. Curr Cardiol Rev 2008;4:101-6.
7. Kim ES, Wattanakit K, Gornik HL. Using the ankle-brachial index to diagnose peripheral artery disease and assess cardiovascular risk. Cleve Clin J Med 2012;79:651-61.
8. Paraskevas K, Phillips M, Shearman C. Screening for peripheral arterial disease using the ankle-brachial index in diabetic and other high-risk patients. Angiology 2015;67:607-9.
9. Creager MA, Lüscher TF, Cosentino F, Beckman JA. Diabetes and vascular disease: Pathophysiology, clinical consequences, and medical therapy: Part I. Circulation 2003;108:1527-32.
10. Gajjala PR, Sanati M, Jankowski J. Cellular and molecular mechanisms of chronic kidney disease with diabetes mellitus and cardiovascular diseases as its comorbidities. Front Immunol 2015;6:340.
11. Slovut DP, Sullivan TM. Critical limb ischemia: Medical and surgical management. Vasc Med 2008;13:281-91.
12. Solaiman FA, Almahameed A, Bartholomew JR. Peripheral arterial disease. Curr Clin Med 2010;2010:196-204.
13. Swierzewski SJ. Peripheral artery disease: Signs and symptoms. Healthc Technol 2003;42:74-112.

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