

Original Research Article

ANKLE BRACHIAL INDEX AS A PREDICTOR OF SILENT MYOCARDIAL ISCHEMIA IN ASYMPTOMATIC TYPE 2 DIABETES MELLITUS PATIENTS

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ABSTRACT

Background: Coronary artery disease usually remains asymptomatic in type 2 diabetes mellitus (T2DM) due to diabetic cardiac autonomic neuropathy. This study evaluates whether the ankle-brachial index (ABI) can serve as a non-invasive predictor of silent myocardial ischemia (SMI) in asymptomatic T2DM patients.

Materials and Methods: A cross-sectional study was conducted among 100 asymptomatic T2DM patients aged 37–60 years without prior cardiovascular disease. ABI was evaluated using continuous-wave Doppler ultrasonography (abnormal defined as ≤ 0.90). Inducible ischemia was assessed via a treadmill test (TMT) using the Bruce protocol. Clinical parameters, glycemic control (HbA1c) and lipid profiles were analyzed.

Results: SMI was detected in 17% of patients. A low ABI (≤ 0.90) was observed in 14% of the cohort. Low ABI showed an 82.35% sensitivity, 100% specificity, 100% positive predictive value, and 96.51% negative predictive value for identifying SMI. Mean ABI was significantly lower in the SMI group compared to the non-SMI group (0.87 ± 0.19 vs. 1.14 ± 0.09 , $p < 0.0001$). Patients with SMI had a significantly longer duration of diabetes (11.41 ± 3.45 vs. 5.13 ± 3.38 years, $p < 0.0001$), higher HbA1c ($p = 0.0021$), higher BMI ($p < 0.01$), and higher prevalence of dyslipidemia ($p = 0.0027$).

Conclusion: A low ABI is strongly associated with SMI, reflecting widespread subclinical atherosclerotic vascular disease. Doppler-derived ABI is an effective, inexpensive, non-invasive screening tool to stratify cardiovascular risk and detect silent coronary artery disease early in asymptomatic T2DM patients.

Keywords: Myocardial Ischemia, Type 2 DM, Ankle Brachial Index, Treadmill.

INTRODUCTION

Diabetes Mellitus is an important risk factor for the development of coronary artery disease (CAD) and it accounts for about 75% of death.^[1,2] Patients with diabetes develop CAD at an accelerated rate and have a higher incidence of heart failure, myocardial infarction and cardiac death compared to non-diabetics.^[3] People with diabetes have a two to three fold greater morbidity and mortality following a myocardial infarction.^[3] Although diabetic patients have a higher prevalence of traditional CAD risk factors such as hypertension, dyslipidemia and obesity when compared with people without diabetes, these risk factors account for less than half the excess

mortality associated with diabetes. Thus, the diagnosis of diabetes is a major independent risk factor for the development of CAD and for adverse outcomes following a cardiovascular event.

In general, CAD in diabetic patients is detected at an advanced stage, whereas the disease in its premature, asymptomatic stages remains undetected.^[4] CAD in diabetes is associated with generalized endothelial dysfunction and abnormalities of small vessels as well. Diabetic patients, more frequently have multiple coronary vessels involved by the time coronary artery disease is diagnosed or at the time of myocardial infarction. Diabetic patients are more prone for developing congestive heart failure because of the more diffuse coronary atherosclerotic process,

particularly in the post myocardial infarction setting.^[5]

Routine clinical practice requires a simple, non-invasive method such as the ankle-brachial index (ABI) to effectively screen for early arterial stiffness and subclinical atherosclerosis. Decreased ABI is strongly associated with cardiovascular diseases.^[6,7] An elevated ABI value seems to be a significant risk factor of CVD.^[8] The ankle brachial index (ABI) is widely accepted as a diagnostic test used to evaluate the presence of lower extremity peripheral artery disease (PAD) in patients with symptoms of intermittent claudication or rest ischemia.^[9]

Assessing the ankle-brachial index (ABI) as a predictor of silent myocardial ischemia in asymptomatic Indian patients with type 2 diabetes is therefore essential for earlier risk identification of adverse cardiovascular outcomes.

MATERIALS AND METHODS

The present study was a cross sectional study carried out between May and November 2011 on patients who were admitted to the Rajiv Gandhi Government General Hospital, Chennai, a tertiary care referral hospital in Tamilnadu with the aim to assess ankle brachial index (ABI) as a predictor of silent myocardial ischemia in asymptomatic type 2 DM patients.

One hundred (100) patients admitted to the various medical wards and attending the outpatient clinics of Rajiv Gandhi Government General Hospital, Chennai were enrolled for the present study.

Primary Objectives

1. To measure ankle brachial index (ABI) using hand held Doppler in asymptomatic type 2 DM patients.
2. To assess the presence of silent myocardial ischemia (SMI) in asymptomatic type 2 DM patients.
3. To evaluate the relationship between ankle brachial index (ABI) and silent myocardial ischemia (SMI) in asymptomatic type 2 DM patients.

Secondary Objectives: To assess the risk factors associated with development of silent myocardial ischemia in asymptomatic type 2 DM patients.

Inclusion Criteria

- Patients with type 2 DM without established cardiovascular symptoms and disease (as per the records available with them).
- Patients willing to give consent and participate in this study

Exclusion Criteria

- Patients with type 2 DM with previous history of established cardiovascular disease.(as per the records available with them)
- Patients with type 2 DM with cardiac symptoms (angina and angina equivalents)
- All type 1 DM patients
- Patients with established/clinically manifested calcification of peripheral arteries

- Patients with vasculitis
- Patients with type 2 DM with established PAD in the form of gangrene and amputation in legs.

Each patient was interviewed to obtain detailed history and examined thoroughly including all peripheral pulses and bruit. Height, weight and waist circumferences were examined with standardized techniques and equipments. BMI and Waist hip ratios were computed. BMI calculated by dividing weight (in kg) by the square of height (in m²). BMI <18.5 - underweight, 18.5-22.9 - normal, 23-24.9 - overweight, >25 - obese. Blood pressure was measured in sitting position in the right upper limb. Serum total cholesterol and triglycerides measurement were done after 12 hours of fasting. Fasting and post prandial blood sugar, HbA1c, serum creatinine was done in all patients. ECG and Echocardiographic evaluation were done to rule out the presence of previous heart disease. Treadmill test was done for all patients in Department of Cardiology following the BRUCE protocol under the supervision of a well experienced cardiologist.

Ankle-Brachial Index (ABI) were measured in a temperature controlled room (24° ± 1 °C) by an examiner with experience in ABI measurement and who was blinded to all clinical baseline parameters. Doppler assisted ABI measurements were performed according to the method described by Lovelace and Moneta¹⁰ using a sphygmomanometer with a cuff width ranging between 29 and 40 cm and a Doppler device with an 8.2 MHz continuous wave probe.

An appropriate sized blood pressure cuff was placed on the arm with the limb at the level of the heart. Ultrasound gel was placed over the patient's brachial pulse. Transducer of the handheld Doppler was placed on the gel and the position of the transducer was adjusted till the maximum intensity of the signal was obtained. The cuff was inflated to about 20mmHg above the expected systolic BP of the patient till the doppler signal was disappeared. Then the cuff was slowly deflated approximately 1mmHg/sec until the Doppler signal re-appears. This was taken as the brachial systolic pressure. Similarly brachial systolic BP was measured in other upper limb.

In lower limbs, an appropriate sized blood pressure cuff was applied immediately proximal to the medial malleoli. The ultrasound gel was placed on the skin overlying the dorsalis pedis (DP) and posterior tibial (PT) arteries in the foot. Transducer of the handheld Doppler was placed on the gel and the position of the transducer was adjusted till the maximum intensity of the signal was obtained. Then the cuff was slowly inflated till no longer the signal was heard. Then the cuff was deflated using the same technique used in the arms until the Doppler signal re-appears. This measurement was taken as systolic BP in DP of that limb. Similarly the systolic pressure of the PT was obtained. The same was repeated on the opposite leg. Calculated ABI values were adjusted to 2 decimal places.

The diagnostic criteria for PAD11 based on the ABI are interpreted as follows:

- Normal if 0.91–1.30
- Mild obstruction if 0.70–0.90
- Moderate obstruction if 0.40–0.69
- Severe obstruction if < 0.40
- Poorly compressible if > 1.30.

RESULTS

In this cross-sectional study of 100 asymptomatic Type 2 Diabetes Mellitus (T2DM) patients, the age of the selected for the study ranges from 37 to 60 years. Among the study population 43 had hypertension. Largest number of hypertensive 25 (58.14%) were in the 50-60 years age group. In the current study 49 of them belongs to overweight and obese category and 51 of them belongs to normal and underweight category. As age increases there is no significant increase in BMI and majority 31(60.78%) of the 51-60 years age group were normal and underweight. Among the 56 males 44(78.57%) of them have HbA1c ≥ 7 and 33 (75%) out of the 44 females were having HbA1c ≥ 7 . Eventhough it appears as males having poor control of blood sugar than males the difference was not statistically significant. Silent myocardial ischemia (SMI)—evaluated via Treadmill Test (TMT) positivity—was detected in 17% of patients.

Among the 100 patients studied only 14 of them having low ABI (≤ 0.9). 81 of them belongs to normal ABI (0.91-1.3) category and the remaining 5 of them belongs to high ABI (> 1.3) category. There was not much significant difference between males and females.

A low Ankle-Brachial Index (≤ 0.9) demonstrated a very strong association with SMI ($p < 0.0001$). Of the 17 patients with SMI, 82.35% (14/17) had an ABI ≤ 0.9 , whereas zero patients in the non-SMI group had an ABI ≤ 0.9 . Mean ABI was significantly lower in the SMI cohort (0.87 ± 0.19 vs. 1.14 ± 0.09 , $p < 0.0001$). Patients with SMI exhibited significantly longer duration of diabetes (11.41 ± 3.45 vs. 5.13 ± 3.38 years, $p < 0.0001$), poorer glycemic control (HbA1c 8.51 ± 1.15 vs. 7.57 ± 1.10 , $p = 0.0021$), higher prevalence of dyslipidemia (88.24% vs. 48.19%, $p = 0.0027$), higher mean BMI (25.52 ± 1.66 vs. 22.56 ± 0.38 [" kg/m"] ^{2} , $p < 0.01$), and higher waist circumference (88.59 ± 12.65 vs. 83.46 ± 8.09 cm" , $p = 0.0346$). Smoking ($p = 0.5768$), alcohol consumption ($p = 0.7815$), gender distribution ($p = 1.000$), waist-to-hip ratio ($p = 0.8465$), and hypertension ($p = 0.0613$) did not show statistically significant associations with SMI. Sensitivity of "ABI" ≤ 0.9 for SMI: 82.35% (14/17) and Specificity of "ABI" ≤ 0.9 for SMI: 100% (83/83).

Table 1: Comprehensive Baseline Comparison Between SMI and Non-SMI Cohorts

Clinical Parameter	NO SMI (n=83)	SMI Present (n=17)	P VALUE	Significance
Age (years)	49.87 $\pm$ 6.22	54.24 $\pm$ 3.11	0.0059*	Significant
DM Duration(Years)	5.13 $\pm$ 3.38	11.41 $\pm$ 3.45	<0.0001*	Highly Significant
BMI	22.52 $\pm$ 1.66	22.56 $\pm$ 0.38	<0.0100*	Highly Significant
W/H RATIO	0.8917 $\pm$ 0.07	0.8882 $\pm$ 0.01	0.8465	Not Significant
WC	83.46 $\pm$ 8.09	88.59 $\pm$ 12.65	0.0346*	Significant
Dyslipidemia(n(%))	40(48.19%)	15(88.24%)	0.0027*	Significant
Hypertension(n(%))	32(38.55%)	11(64.71%)	0.0613	Not Significant
Active Smoking(n(%))	27(32.53%)	7(41.18%)	0.5768	Not Significant
Alcoholism(n(%))	30(36.14%)	5(29.41%)	0.7815	Not Significant
HbA1c	7.57 $\pm$ 1.1031	8.51 $\pm$ 1.1459	0.0021*	Significant
ABI	1.14 $\pm$ 0.09	0.87 $\pm$ 0.2	<0.0001	Highly Significant

Table 2: Cross-Tabulation of Ankle-Brachial Index and Silent Myocardial Ischemia (TMT Status)

ABI Category	Positive TMT / SMI (n=17)	Negative TMT / No SMI (n=83)	Total (N=100)	Positive Predictive Value
≤ 0.9 (Low ABI)	14 (82.35%)	0 (0.00%)	14	100%
> 0.9 (Normal/High ABI)	3 (17.65%)	83 (100.00%)	86	—
Total	17 (100.00%)	83 (100.00%)	100	Fisher's Exact $p < 0.0001$

DISCUSSION

Silent myocardial ischemia (SMI) poses a major diagnostic and therapeutic problem among patients with type 2 diabetes mellitus (T2DM). The primary cause of the blunting of cardiac nociception is diabetic cardiac autonomic neuropathy (CAN), frequently leaves advanced coronary atherosclerosis clinically inactive until presenting as acute myocardial infarction, malignant arrhythmias or sudden cardiac death. The present cross-sectional observational study evaluated whether Ankle-Brachial Index (ABI) an inexpensive, non-invasive

substitute marker of generalized systemic atherosclerosis can serve as a reliable clinical predictor of SMI among asymptomatic T2DM individuals.

Among the 100 asymptomatic diabetic individuals included in our study, the Treadmill Test (TMT) identified inducible myocardial ischemia in 17 participants (17%). This finding is consistent with observations from previous studies, which have reported the prevalence of silent myocardial ischemia (SMI) among asymptomatic diabetic patients to be approximately 10–25%. The variation in prevalence across studies may be related to differences in the

screening methods used, including exercise stress testing, stress echocardiography, and myocardial perfusion imaging.

In the landmark Detection of Ischemia in Asymptomatic Diabetics (DIAD) study, Wackers et al. (2004) reported evidence of silent ischemia in 22% of asymptomatic patients with type 2 diabetes mellitus who underwent adenosine myocardial perfusion imaging (MPI).^[12] Comparable findings have also been reported by investigators of the Milan Study on Atherosclerosis and Diabetes (MiSAD), who observed rates of approximately 15–20% using exercise ECG stress testing.^[13] Similar results were also reported by Janand-Delenne et al.^[14] These findings suggest that silent myocardial ischemia is common among individuals with diabetes who may otherwise have no symptoms suggestive of underlying coronary artery disease.

The primary objective of the present study was to examine the relationship between the ankle-brachial index (ABI) and silent myocardial ischemia (SMI). An ABI of ≤ 0.90 , suggestive of peripheral arterial disease, was observed in 14% of the study participants. Association was noted between a reduced ABI and evidence of SMI on treadmill testing. Of the 17 participants who had a positive TMT, 14 (82.35%) had an ABI ≤ 0.90 , while the remaining 3 (17.65%) had an ABI within the normal range. In contrast, none of the 83 participants with a negative TMT had an ABI ≤ 0.90 .

The mean ABI was also considerably lower among participants with SMI than among those without SMI (0.87 ± 0.19 versus 1.14 ± 0.09 , respectively), and this difference was statistically significant ($p < 0.0001$). The diagnostic analysis further demonstrated that an ABI ≤ 0.90 had a sensitivity of 82.35% (95% CI: 56.57–96.20%) and a specificity of 100% (95% CI: 95.65–100%) for identifying SMI in this study population. The positive predictive value was 100%, while the negative predictive value was 96.51%.

The observed association between reduced ABI and SMI supports the concept that peripheral arterial disease should not be regarded as a condition confined to the peripheral circulation. Instead, it may serve as a marker of more widespread atherosclerotic involvement, including the coronary circulation. Our findings are consistent with those reported by Papazafiropoulou et al. (2010), who found that an ABI ≤ 0.90 was associated with subclinical coronary artery disease and abnormalities on myocardial perfusion imaging among patients with diabetes.^[15] Findings from the Strong Heart Study have similarly demonstrated that a low ABI is independently associated with subsequent coronary events and cardiovascular mortality in both diabetic and non-diabetic populations.^[16]

An ABI greater than 1.30 was observed in five participants in the present study. Such elevated values may indicate medial arterial calcification, or Monckeberg's arteriosclerosis in which arterial walls become stiff and less compressible. This vascular

change is frequently seen in individuals with longstanding diabetes and may result in an apparently elevated ABI despite underlying arterial disease. It is also considered an important marker of increased cardiovascular risk.^[17]

A clear relationship was observed between the duration of diabetes and the presence of silent myocardial ischemia (SMI). All 17 patients with SMI had diabetes for more than 5 years, with a significantly longer mean duration of diabetes than those without SMI (11.41 ± 3.45 vs. 5.13 ± 3.38 years, $p < 0.0001$). Similarly, all 14 participants with an ABI ≤ 0.90 had diabetes for more than 5 years ($p < 0.0001$). These findings suggest that prolonged exposure to hyperglycemia may contribute to progressive vascular injury through mechanisms such as accumulation of advanced glycation end-products, endothelial dysfunction, and vascular remodeling.^[18]

Glycemic control also differs significantly between the two groups. Poor glycemic control (HbA1c $\geq 7\%$) was present in 77% of the study population. Participants with SMI had higher mean HbA1c levels than those without SMI ($8.51 \pm 1.15\%$ vs. $7.57 \pm 1.10\%$, $p = 0.0021$). All participants with an ABI ≤ 0.90 had HbA1c levels $\geq 7\%$. These observations are consistent with the findings of the UKPDS 35 analysis, which demonstrated a progressive relationship between glycemic exposure and the risk of diabetic complications, including myocardial infarction and microvascular disease.^[19]

Dyslipidemia was significantly more common among participants with SMI than among those without SMI (88.24% vs. 48.19%, $p = 0.0027$). The high prevalence of dyslipidemia in the SMI group may reflect the contribution of an atherogenic lipid profile to coronary plaque development and progression.^[20]

Measures of adiposity also showed some differences between the groups. Mean BMI was higher among participants with SMI (25.52 ± 1.66 vs. 22.56 ± 0.38 kg/m², $p < 0.01$), while waist circumference was also significantly greater (88.59 ± 12.65 vs. 83.46 ± 8.09 cm, $p = 0.0346$). However, the waist-to-hip ratio did not differ significantly ($p = 0.8465$). These findings suggest that overall and central adiposity may have a role in cardiovascular risk among patients with diabetes, mainly through chronic inflammation and endothelial dysfunction.^[21]

CONCLUSION

This study was able to establish that a simple, cost effective and non-invasive investigation like ABI can predict the presence of asymptomatic CAD in type 2 diabetics. This is more relevant in a developing country like India where the economic resources available with the common man preclude other invasive and costlier modalities of screening for asymptomatic patients. Even though the benefits of early detection of the asymptomatic disease and its

treatment has not yet yielded a significant benefit to patients in the studies conducted so far, it remains to be decided only after long term studies with larger populations. Till then, in our country simple and effective measures available for primary prevention is the only way forward as prevention is always better than the cure.

Limitations: Being a cross-sectional study, it only shows a link between low ABI and silent ischemia at one moment. With just 100 patients (and only 17 with silent ischemia), the numbers are too small to draw firm and broad conclusions. Also Patients came from a single tertiary hospital, findings may reflect Berkson's bias (selection bias) and cannot be generalized to broader community.

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