Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

Role of Color Doppler Ultrasound Imaging in Assessment of Peripheral Arterial Disease of Lower Limb Arteries in Patients with Type 2 Diabetes Mellitus

Kamlesh Prasad Gupta[1], Rajesh Kumar Singhai[2], Priyanka Tiwari[3], Sonal Gupta[4]

[1]Associate Professor and HOD, Department of Radio Diagnosis, Sukh Sagar Medical College and Hospital, Jabalpur, Madhya Pradesh, India, [2]Assistant Professor, Department of Emergency Medicine, Sukh Sagar Medical College, Jabalpur, Madhya Pradesh, India, [3]Associate Professor, Department of Pathology, Sukh Sagar Medical College, Jabalpur, Madhya Pradesh, India, [4]Senior Resident, Department of Radiodiagnosis, Gandhi Medical College, Bhopal, Madhya Pradesh, India

Abstract

Introduction: Diabetes mellitus is one of the major health problems in India as well as in the world in the 21st century. Vascular complications are one of the major causes of morbidity and mortality in type II diabetic patients, among which peripheral arterial disease is of major concern. The prevalence of peripheral arterial disease in patients with diabetes is affected by multiple host factors, which include age, sex, duration of diabetes, level of glycemic control, dyslipidemia, smoking, hypertension, and obesity. With the help of color Doppler imaging, it is possible to detect the exact site and extent of the lesion affecting the peripheral arteries, and the Doppler findings are also helpful for planning surgical versus medical management.

Materials and Methods: This was a hospital-based cross-sectional study done in June 2022–June 2023 at the Department of Radio-diagnosis. The study sample consisted of 245 adult type II diabetic patients within the age group of 18–65 years with a history of diabetes of at least 5 years duration attending the radiology department and being referred from the department of endocrinology. After a brief history and clinical examination, an ultrasound (USG) color Doppler study of bilateral lower limb arteries was conducted in these type 2 diabetes patients to look for peripheral arterial disease.

Results: In the present study, out of 245 patients, 60 (24.5%) had peripheral artery disease (PAD) ($Z = 8.26$; $P < 0.0001$), so the prevalence of PAD was 24.5% amongst type 2 diabetes mellitus patients. Out of those 60 patients, only 4 (1.7%) had total arterial occlusion.

Conclusion: Color doppler USG remains an accurate, safe, cost-effective, repeatable, non-invasive procedure for investigating lower limb arteries. Color Doppler sonography can be used to classify peripheral arterial disease into hemodynamically significant and non-significant using peak systolic velocity, peak systolic velocity ratio, and spectral waveforms, which will help in further management.

Key words: Colour doppler, Disease, Ultrasound

INTRODUCTION

Diabetes mellitus is one of the major health problems in India as well as in the world in the 21st century. It is a major public health problem that affects all levels of society, regardless of age, gender, race, or ethnicity. According to the predictions, the global prevalence of diabetes is going to double globally, from 171 million in 2000 to 366 million in 2030, with a maximum increase in India.[1] Vascular complications are one of the major causes of morbidity and mortality in type II diabetic patients, among which Peripheral arterial disease is of major concern because it is associated with an increased risk of lower extremity amputation and is also a marker for atherothrombosis in cerebrovascular, cardiovascular, and renovascular beds. It is the most common disease affecting the lower limb

Access this article online

www.ijss-sn.com

Month of Submission : 09-2023
Month of Peer Review : 09-2023
Month of Acceptance : 10-2023
Month of Publishing : 11-2023

Corresponding Author: Dr. Sonal Gupta, Department of Radiodiagnosis, Gandhi Medical College, Bhopal, Madhya Pradesh, India.

arteries and causes a reduction in arterial supply secondary to occlusion of the arterial lumen. The prevalence of peripheral arterial disease in patients with diabetes is affected by multiple host factors, which include age, sex, duration of diabetes, level of glycemic control, dyslipidemia, smoking, hypertension, and obesity.[2] Although the gold standard for diagnosing peripheral artery disease (PAD) is angiography, the use of this technique is limited because of its invasive nature. With the help of color Doppler imaging, it is possible to detect the exact site and extent of the lesion affecting the peripheral arteries, and the Doppler findings are also helpful for planning surgical versus medical management.[3] It is a valid investigation that can provide a dynamic assessment of the hemodynamic status of the vessel. It is also an economic, widely available, non-invasive investigation that allows the detection of peripheral arterial disease at an early stage. It can show the exact flow velocity of each arterial segment and determine the degree of severity of the stenosis based on the analysis of the pulsed wave Doppler spectral waveform [Tables 1-4].

MATERIALS AND METHODS

Study Area

Department of Radio-diagnosis, Sukh Sagar Medical College and Hospital Jabalpur (MP)

Study Design

Hospital-based cross-sectional study.

Study Period

June 2022–June 2023

Study Population

Inclusion criteria

All adult type II diabetic patients within the age group of 18–65 years with a history of diabetes of at least 5 years duration attending the radiology department and referred from the department of endocrinology

Exclusion criteria

- Age <18 years and >65 years,
- Non-diabetic patients,
- Type I diabetic patients,
- Critically ill and moribund diabetic patients,
- Past history of any vascular surgery of the lower limbs,
- Other diseases known to cause peripheral vascular abnormalities are scleroderma, SLE and Buerger's disease.

Sample Size

245 type 2 diabetes patients (based on a statistically significant calculation).

Method of the Study

Once the patient agrees for the study, informed consent was taken beforehand. Then a preformed proforma was used to record the patient's details, clinical history, physical examination, and investigations. Then the peripheral arterial system was examined by an ultrasound (USG) color Doppler imaging study to assess the arterial wall changes, flow pattern, flow velocity, detect stenosed segments, and diagnose and assess the severity of peripheral arterial disease.

Study Tools

- USG machine-Philips HD7 machine with 3–12 MHz linear transducer, GE LOGIQ P9 machine with 3–12 MHz linear transducer.
- A preformed proforma for recording patient details, clinical history, examination findings, color Doppler, and other investigation findings.

A thorough history was taken, which included age, sex, history of smoking, duration of disease, and treatment taken by the patient for diabetes (oral hypoglycemic drugs, insulin, or a combination of either of these).

Clinical examination included

- General examination that includes blood pressure measurement,
- Systemic examination
- Local examination includes measurement of ABPI.

ABPI was measured in both limbs, by the bedside of the patient, and the ratio was calculated by dividing the highest pressure measured in the ankle (signifying tibial artery pressure) by the highest pressure measured in the arm (signifying brachial artery pressure).

Routine blood investigations included fasting blood sugar, hemoglobin A1C (HbA1c), and other relevant blood investigations.

Radiological Procedure

The procedure begins with the patient lying supine. The decubitus position may aid in the evaluation of the popliteal artery. With the help of the linear transducer (3-12 MHz), a grayscale evaluation of the peripheral arteries of the lower limbs was done first to assess the arterial wall changes and atherosclerotic changes.

Then the individual arterial segments of the lower limbs were examined with color Doppler to find out the pattern of color uptake and to find out if there was any stenosis. Spectral Doppler was used to assess the flow velocity and flow pattern to diagnose and assess the severity of peripheral arterial disease.

Table 1: Distribution of patients based on percentage of stenosis

Status of stenosis (%)	Number	%
No stenosis	80	32.7
0–50	105	42.9
51–75	50	20.4
>75	6	2.4
Total occlusion	4	1.6
Total	245	100.0

Table 2: Distribution of patients based on peak systolic velocity ratio (PSV ratio)

PSV ratio	Number	%
<1.5:1	80	32.7
1.5–2:1	105	42.9
2.0–4.0:1	50	20.4
>4.0:1	6	2.4
Total occlusion	4	1.6
Total	245	100.0

Table 3: Distribution of peripheral artery disease (PAD) in the study population

PAD	Number	%
Positive	60	24.5%
Negative	185	75.5%
Total	245	100.0%

Table 4: Flow pattern in post stenotic segment and status of PAD of the patients

Flow pattern in post stenotic segment	With PAD	Without PAD	Total
Absent flow	4	0	4
Biphasic	0	27	27
Monophasic	56	0	56
Triphasic	0	78	78
Not assessed	0	80	80
Total	60	185	245

χ^2=245.00; *P*<0.0001 S-significant. PAD: Peripheral artery disease

Table 5: Diagnostic distribution of the patients as per ABPI

ABPI	Number	%
≥1.0	120	49.0
0.91–0.99	77	31.4
0.41–0.90	45	18.4
≤0.40	3	1.2
Total	245	100.0

RESULTS

In the present study, among 250 patients, most of the patients (75.1%) were above 45 years of age, which was significantly higher (Z = 7.78; $P < 0.0001$). The youngest patient was a 24-year-old female, and the eldest was a 65 year-old male.

The ratio of male to female (male: female) was 1.5:1.0. A test of proportion showed that the proportion of males (59.2%) was significantly higher than that of females (40.8%) (Z = 3.67; $P < 0.001$).

On categorizing patients based on percentage of stenosis, 24.4% of the patients had stenosis >50% (Z = 5.22; $P < 0.0001$).

Among the patients studied, 24.4% of the patients had PSV ratio >2:1.

Out of 245 patients, 60 (24.5%) patients had PAD (Z = 8.26; $P < 0.0001$).

Table 6: Diagnostic distribution of the patients as per the USG Doppler study

PAD	Number	%
Present	60	24.5
Absent	185	75.5
Total	245	100.0

USG: Ultrasound

Table 7: Comparison of number of findings of peripheral arterial disease by color Doppler imaging of lower limb arteries and ABPI

Comparison	Number	%
TP	40	16.3
TN	177	72.2
FN	20	8.2
FP	8	3.3
Total	245	100.0

TP: True positive, TN: True negative, FN: False negative, FP: False positive

Table 8: Duration of T2DM and status of PAD of the patients

Duration of T2DM (In years)	With PAD	Without PAD	Total
≥10	39	111	150
<10	21	74	95
Total	60	185	245

χ^2=13.76; *P*<0.001 S-significant. PAD: Peripheral artery disease

Table 9: Level of FBS and status of PAD of the patients

Level of FBS (in mg/dl)	With PAD	Without PAD	Total
>126	48	67	115
≤126	12	118	130
Total	60	185	245

χ^2=34.87; *P*<0.0001 S-significant. PAD: Peripheral artery disease

6.7% and 93.3% of the patients with PAD had absent flow and monophasic, respectively, which were significantly higher than the patients with no PAD ($Z = 9.11$; $P < 0.0001$).

An ABPI <0.9 is also used as a cut off value for the diagnosis of PAD in present study for the comparison with Doppler study. Using ABPI, out of 245 patients, 48 (19.6%) patients were diagnosed as having PAD.

Out of 60 patients who were diagnosed to have PAD based on the color Doppler USG, only 40 (66.7%) were categorized as having PAD by the ABPI method. Thus, the remaining 20 (33.3%) patients would have remained undiagnosed if ABPI alone were used for the diagnosis of PAD.

Conversely, 8 (16.7%) patients out of 48 were diagnosed with PAD by ABPI and were classified as normal by the color Doppler USG.

Diagnostic Accuracy = (TP + TN)/TOTAL CASES × 100 = 88.57%
Sensitivity = TP/(TP + FN) × 100 = 66.67%
Specificity = TN/(TN + FP) × 100 = 95.68%
Positive predictive value = TP/(TP + FP) × 100 = 83.33%
Negative Predictive Value = TN/(TN + FN) × 100 = 89.85%

However, the risk of PAD was 3.81 times more among the patients with a duration of T2DM ≥10 years as compared to the patients with a duration of T2DM <10 years, and the risk was significant (OR–3.81 [1.82, 7.97]; $P < 0.0001$).

However, the risk of PAD was 7.04 times more among the patients with a higher level of FBS >126 mg/dL as compared to the patients with a level of FBS ≤126 mg/dL, and the risk was significant (OR–7.04 [3.49, 14.18]; $P < 0.0001$).

Table 10: Assessment of different risk factors associated with PAD of the patients

Parameters	Odds ratio (OR) with 95% confidence Interval	*P*-value
Age >50 years	OR–1.23 (0.67, 2.27)	0.48NS
Female	OR–1.37 (0.76, 2.47)	0.28NS
Duration of T2DM >10 years	OR–3.81 (1.82, 7.97)	<0.0001S
BMI ≥25 kg/m^2	OR–4.22 (2.91, 9.74)	<0.0001S
SBP >140 mmHg	OR–1.73 (0.94, 3.19)	0.07NS
DBP >90 mmHg	OR–3.46 (1.78, 6.73)	<0.0001S
Smoking	OR–1.22 (0.68, 2.20)	0.49NS
Symptomatic	OR–6.48 (3.30, 12.73)	<0.0001S
Total cholesterol >200 mg/dL	OR–4.92 (2.55, 9.49)	<0.0001S
TG >150 mg/dL	OR–10.80 (5.30, 21.98)	<0.0001S
HDL<40 mg/dL	OR–3.78 (2.05, 6.93)	<0.0001S
FBS >126 mg/dL	OR–7.04 (3.49, 14.18)	<0.0001S
HbA1c >6.5%	OR–4.92 (2.55, 9.49)	<0.0001S
LDL >100 mg/dL	Could not be assessed*	<0.0001S

*Since one of the cell frequencies was zero Chi-square test could not be applied and risk could not be assessed. However, Fisher's exact test showed all the patients with PAD had LDL >100 mg/dl (*P*<0.0001). HbA1c: Hemoglobin A1C

DISCUSSION

In the present study, 150 (61.2%) patients were above 50 years of age, with the youngest being 24 years old and the eldest being 64 years old. The mean age of patients

AQ2

Table 11: Comparison of different parameters of the patients with PAD and without PAD

Parameters	Group	Mean	Std. Deviation	t-test	*P*-value
Age (years)	With PAD (*n*=60)	53.32	8.18	1.12	0.27NS
	Without PAD (*n*=185)	51.94	8.65		
Duration of DM (Years)	With PAD (*n*=60)	13.15	3.52	5.64	<0.001S
	Without PAD (*n*=185)	10.14	3.83		
BMI (kg/m^2)	With PAD (*n*=60)	27.87	2.10	12.72	<0.001S
	Without PAD (*n*=185)	23.67	2.57		
SBP (mmHg)	With PAD (*n*=60)	141.63	9.41	2.94	<0.001S
	Without PAD (*n*=185)	137.36	10.84		
DBP (mmHg)	With PAD (*n*=60)	90.40	5.65	4.10	<0.001S
	Without PAD (*n*=185)	86.84	6.36		
Cholesterol (mg/dL)	With PAD (*n*=60)	255.28	44.73	8.79	<0.001S
	Without PAD (*n*=185)	202.42	22.88		
Triglyceride (mg/dL)	With PAD (*n*=60)	174.92	25.18	8.14	<0.001S
	Without PAD (*n*=185)	147.55	11.66		
LDL (mg/dL)	With PAD (*n*=60)	155.90	22.58	12.80	<0.001S
	Without PAD (*n*=185)	113.13	22.23		
HDL (mg/dL)	With PAD (*n*=60)	37.05	8.19	6.29	<0.001S
	Without PAD (*n*=185)	44.44	6.97		
FBS (mg/dL)	With PAD (*n*=60)	136.62	11.32	8.10	<0.001S
	Without PAD (*n*=185)	124.31	5.60		
HBA1C (%)	With PAD (*n*=60)	7.25	0.80	7.09	<0.001S
	Without PAD (*n*=185)	6.50	0.27		

S: Statistically significant. NS: Statistically not significant, HbA1c: Hemoglobin A1C, Peripheral artery disease

with PAD and patients without PAD was 53.32 ± 8.18 years and 51.94 ± 8.65 years, respectively. It was seen that the risk of PAD was 1.23 times more among the patients aged >50 years as compared to the patients aged 50 years or less; however, the risk was not statistically significant (OR–1.23 [0.67, 2.27]; $P = 0.48$). Similar to other studies,[4,5] the results of the present study showed that the prevalence of PAD increases with increasing age.

Out of 245 patients, 60 (24.5%) were found to have hemodynamically significant stenosis (>50%) in the peripheral arteries of the lower limb by the USG Doppler study. No stenosis was detected in lower limb arteries in 80 (32.6%) patients, and 105 (75.4%) patients were found to have stenosis <50%. So, 185 patients were categorized to have no PAD.

In the present study, a PSV ratio <2:1 was encountered in 185 (75.4%) patients and a PSV ratio >2:1 in 24.6% of the patients.

Among the 60 (24.5%) patients who had significant stenosis (>50%) and a PSV ratio >2:1, 4 (1.7%) patients had total arterial occlusion.

Therefore, the results of the present study showed the prevalence of PAD to be 24.5%.

The prevalence of PAD in the current study is higher than the result of a study done in Coastal Karnataka, India (8.5%)[6] and South India (16.5%).[7] It is imperative to note that this difference is attributable to the type of diagnostic tool used. Color Doppler USG was used as the gold standard in the current study, which, in modern day practice, is considered to be the most superior diagnostic technique compared with other diagnostic methods like the ankle-brachial index, which can underestimate the prevalence of PAD.[8] Another reason for the high prevalence of PAD in the present study is that in many patients, DM co-exists with other risk factors for cardiovascular disease like hypertension, dyslipidemia, and obesity. Secondly, it is likely that patients with DM who present at the tertiary hospital have been referred owing to the chronic complications of DM.

On the other hand, the prevalence of PAD in the current study is lower than that of the studies done in Uganda (39%)[9] and Pakistan (39.3%).[10] This might be due to a difference in socioeconomic factors, lifestyle, and duration of diabetes among study participants.

In the present study, it was observed that the majority of the cases of vascular stenosis involved arteries below the knee and more so distally. In the present study, among the patients with PAD, ADP was the most commonly involved artery (23.3%), followed by distal ATA (18.3%) ($Z = 4.20$; $P < 0.0001$).

A review of existing literature also showed similar findings: distal small arteries are more frequently involved in diabetics.[11,12] Logerfo and Coffman[13] stated in their study that arterial occlusion commonly involves the tibial arteries (calf vessels).

In the present study, the mean duration of diabetes in patients with PAD and in patients without PAD was 13.15 ± 3.52 years and 10.14 ± 3.83 years, respectively. Patients with PAD had a significantly longer duration of diabetes as compared to those without PAD ($P < 0.001$).

Also, the risk of PAD was 3.81 times more among the patients with a duration of Type 2 DM ≥10 years as compared to the patients with duration of Type 2 DM <10 years, which is also statistically significant (OR–3.81 [1.82, 7.97]; $P < 0.0001$).

This finding is in accordance with the pathogenesis model of microvascular and macrovascular complications proposed by Fowler,[14] who considered sustained hyperglycemia to be responsible for both microvascular and macrovascular complications in diabetics. The association between the duration of diabetes and PAD has been highlighted by numerous studies.[15-18] Thus, duration of disease seems to be an empirical risk factor supported by a large body of previous research, which is revalidated in the present study.

In the present study, out of 245 patients, 195 were found to be asymptomatic. 32 patients in the asymptomatic category was ultimately found to have sonographic features of PAD. Among the 50 symptomatic patients, 28 had PAD. So, the prevalence of PAD among the asymptomatic group and the symptomatic group was 19.60% and 56%, respectively.

From the above, it was calculated that the risk of PAD was 6.48 times more among the symptomatic patients as compared to the asymptomatic patients, which was statistically significant (OR–6.48 [3.30, 12.73]; $P < 0.0001$).

The mean FPS in patients with PAD was 136.62 ± 11.32 and in those without PAD was 124.31 ± 5.60. It was observed that FPS is higher in patients with PAD than without PAD, which is statistically significant ($P < 0.001$).

The risk of PAD was 7.04 times more among the patients with a level of FBS >126 mg/dL as compared to the patients with a level of FBS≤126 mg/dL, and the risk was statistically significant (OR–7.04 [3.49, 14.18; $P < 0.0001$).

The results of the present study correlate with other studies from Asia, where a significant association was noted between hyperglycemia and PAD.[19,20]

The majority of the patients in the present study had well-controlled diabetes. The mean HbA1c in the present study population was 6.68 ± 0.56%.

A comparative study between the two groups showed that the mean HbA1c in the PAD category was 7.25 ± 0.80% ($P < 0.001$), which was significantly higher than in the non-PAD category (mean HbA1c 6.50 ± 0.27%).

The risk of PAD was 4.92 times more among the patients with HbA1c >6.5%, which was significantly higher as compared to the patients with HbA1c≤6.5% (OR–4.92 [2.55, 9.49]; $P < 0.0001$).

Walter *et al.*[21] and Janka *et al.*[22] encountered similar findings in their study and concluded poor glycemic control to be a predictor of PAD.

Therefore, the present study focuses on several significant risk factors involved in the etiopathogenesis of peripheral arterial disease and also gives an estimate of the prevalence of PAD in this region of the Indian subcontinent [Tables 5-11].

CONCLUSION

There is a significant prevalence of PAD in the diabetic population evaluated by us. Most of the patients are asymptomatic or do not show obvious signs of PAD, but they need to be investigated for the same. The prevalence of PAD in the present study is 24.5%.

The peripheral arteries below the knee were more commonly and more severely affected by PAD in diabetic patients. In the present study, ADP was found to be most frequently affected.

Increasing age, longer duration of diabetes, increased diastolic blood pressure, poor glycemic control, and an abnormal lipid profile are strong risk factors for PAD.

The detection of PAD in asymptomatic patients as well as in those presenting with signs and symptoms of PAD, using Arterial Doppler studies along with routine clinical and laboratory assessment, with subsequent education and foot care advice and further management, can be of great value in the long-term care of these individuals to prevent ulceration and other complications and thereby reduce morbidity and mortality from PAD in patients with diabetes.

REFERENCES

1. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: Estimates for the year 2000 and projections for 2030. Diabetes Care 2004;27:1047-53.
2. Fowkes FG, Rudan D, Rudan I, Aboyans V, Denenberg JO, McDermott MM, *et al*. Comparison of global estimates of prevalence and risk factors for peripheral artery disease in 2000 and 2010: A systematic review and analysis. Lancet 2013;382:1329-40.
3. Al-Quasi M, Nott DM, King DH, Kaddoura S, Hamady M. Imaging of peripheral vascular disease. Rep Med Imaging 2009;2:25-34.
4. Stoffers HE, Rinkens PE, Kester AD, Kaiser V, Knottnerus JA. The prevalence of asymptomatic and unrecognized peripheral arterial occlusive disease. Int J Epidemiol 1996;25:282-90.
5. Shukla V, Fatima J, Ali M, Garg A. A study of prevalence of peripheral arterial disease in type 2 diabetes mellitus patients in a teaching hospital. J Assoc Physicians India 2018;66:57-60.
6. Arora E, Maiya AG, Devasia T, Bhat R, Kamath G. Prevalence of peripheral arterial disease among type 2 diabetes mellitus in coastal Karnataka. Diabetes Metab Syndr 2019;13:1251-3.
7. Eshcol J, Jebarani S, Anjana RM, Mohan V, Pradeepa R. Prevalence, incidence and progression of peripheral arterial disease in Asian Indian type 2 diabetic patients. J Diabetes Complications 2014;28:627-31.
8. Hur KY, Jun JE, Choi YJ, Lee YH, Kim DJ, Park SW, *et al*. Colour Doppler ultrasonography is a useful tool for diagnosis of peripheral artery disease in type 2 diabetes mellitus patients with ankle-brachial index 0.91 to 1.40. Diabetes Metab J 2018;42:63-73.
9. Mwebaze RM, Kibirige D. Peripheral arterial disease among adult diabetic patients attending a large outpatient diabetic clinic at a national referral hospital in Uganda: A descriptive cross-sectional study. PLoS One 2014;9:e105211.
10. Ali Z, Ahmed SM, Bhutto AR, Chaudhry A, Munir SM. Peripheral artery disease in type II diabetes. J Coll Physicians Surg Pak 2012;22:686-9.
11. Haimovici H. Peripheral arterial disease in diabetes mellitus. In: Ellenberg M, Rifkin H, editors. Diabetes Mellitus: Theory and Practice. New York: McGraw-Hill; 1970. p. 890-911.
12. Penn I. The impact of diabetes mellitus on extremity ischemia. In: Kempinsky RF, editor. The Ischemic Leg. Chicago: Year Book Medical Publishers; 1985. p. 56-69.
13. LoGerfo FW, Coffman JD. Current concepts. Vascular and microvascular disease of the foot in diabetes. Implications for foot care. N Engl J Med 1984;311:1615-9.
14. Fowler MJ. Microvascular and macrovascular complications of diabetes. Clin Diabetes 2008;26:77-82.
15. Khurana A, Dhoat P, Marwaha TS. Peripheral vascular disease a silent assassin: Rising trend in Punjab. J Indian Acad Clin Med 2013;14:111-4.
16. Amissah I, Antiri EK. The prevalence of lower extremity peripheral artery disease among adults with type 2 diabetes mellitus attending a teaching hospital in Ghana. Int J Sci Res 2016;5:2034-8.
17. Garg KB, Priyanka P, Gupta A, Tak S, Sharma N, Sehra R. A study of ankle brachial index and asymptomatic coronary artery disease in type-2 diabetes mellitus patients. IOSR J Dent Med Sci 2016;15:48-51.
18. Agarwal AK, Singh M, Arya V, Garg U, Singh VP, Jain V. Prevalence of peripheral arterial disease in type 2 diabetes mellitus and its correlation with coronary artery disease and its risk factors. J Assoc Physicians India 2012;60:28-32.
19. Rhee SY, Guan H, Liu ZM, Cheng SW, Waspadji S, Palmes P, *et al*. Multi-country study on the prevalence and clinical features of peripheral arterial disease in Asian type 2 diabetes patients at high risk of atherosclerosis.

Diabetes Res Clin Pract 2007;76:82-92.
20. Wang L, Du F, Mao H, Wang HX, Zhao S. Prevalence and related risk factors of peripheral arterial disease in elderly patients with type 2 diabetes in Wuhan, Central China. Chin Med J (Engl) 2011;124:4264-8.
21. Walter DP, Gatting W, Mullee MA, Hill RD. The prevalence, detection, and correlates of peripheral vascular disease: A comparison of diabetics and non-diabetic subjects in an English community. Diabet Med 1992;9:710-5.
22. Janka HU, Standl E, Mehnert H. Peripheral vascular disease in diabetes mellitus and its relation to cardiovascular risk factors: Screening with the Doppler ultrasonic technique. Diabetes Care 1980;3:207-13.

How to cite this article: Gupta KP, Singhai RK, Tiwari P, Gupta S. Role of Color Doppler Ultrasound Imaging in Assessment of Peripheral Arterial Disease of Lower Limb Arteries in Patients with Type 2 Diabetes Mellitus. Int J Sci Stud 2023;11(8):47-53.

Source of Support: Nil, **Conflicts of Interest:** None declared.