SCIENTIFIC RESEARCH

# COLOR DOPPLER ULTRASOUND WITH DSA CORRELATION IN TYPE 2 DIABETIC PERIPHERAL ARTERIAL DISEASE OF LOWER EXTREMITY

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**SUMMARY**

**Objectives:** Describe imaging characteristics of Duplex ultrasound (DUS) and correlation with digital subtraction angiography (DSA) in the diagnosis of peripheral arterial disease (PAD) of lower extremity in type 2 diabetic patients.

**Materials and Methods:** cross sectional study with 40 patients diagnosed with type 2 diabetes and PAD on DUS. The image findings of both techniques were used to evaluate the diagnosis accuracy of DUS and the correlation with DSA.

**Results:** The sensitivity, specificity, positive predictive value and negative predictive value of DUS in PAD is 80,65%, 92,83%, 86,21% and 89,61% respectively. DSA complemented for DUS with 6,36% additional cases of >50% stenosis or complete occlusion and 5,49% cases of low flow in occlusion suspected arteries. DSA revealed an additional of 81% collaterals in occluded arteries compared to DUS.

**Conclusion:** DUS has high diagnostic value in PAD of lower extremities in diabetes patients. DSA has high complementary value for DUS in the diagnosis of PAD of lower extremities, with the highest value at below-knee arteries.

**Keywords:** *peripheral arterial disease, doppler ultrasound, digital subtraction angiography.*

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## BACKGROUND

Peripheral arterial disease (PAD) of lower extremity is the medical conditions characterized by stenosis or occlusion of arteries that partly or totally obstruct blood blow. The low circulation in the lower limbs led to claudication and consequently gangrene of the affected limbs [8]. This is not a life-threatening condition but its consequence including ulcers, gangrene and limb amputation can disturb life quality if not having early diagnosis and intervention. PAD prevalence increases for 2 to 4 times in patients with diabetes mellitus. Not only the morbidity rate, the disease severity of PAD is also more important in type 2 diabetic patients [9].

There are many imaging modalities for diagnosis of PAD of lower extremity, including Duplex ultrasound (DUS), Computed tomographic angiography (CTA) and Magnetic resonance angipgrahy (MRA). Each method has its own advantages and disadvantages in the diagnosis of PAD. Comparing to angiography, CTA has higher resolusion with volumetric acquisition, which allows assessement of anatomy of peripheral arteries in multiple planes with single acquisition. This imaging technique also depicts tissue abnormalities and is less invasive than angiography, thus fewer complications [10]. Comparing to MRA, CTA has higher spatial resolution with less artificial images, absece of flow-related phenomena and has higher diagnostic value in detecting calcification and metallic implants. Its only disadvantages are ionizing radiation and complications from iodinated contrast administration [10]. MRA also has high resolution images of peripheral arteries with rapid acquisition time if performed by powerful modern MR machines. It also detects stenosis of small vessels with high reliability [10]. Its disadvantages are high cost and lower availability in many hospitals, comparing to DUS or CTA.

Color Doppler ultrasound (DUS) is a reliable method with advantages of being a non-invasive technique, low cost, can be repeated for multiple times and applied widely. However, its sensitivity and specificity are lower comparing to other techniques [2]. Moreover, DUS has many limitations in below-knee arteries due to small diameter arteries, multiple stenosis of upstream arteries that could hinder assessment of downstream arteries. In these cases, angiography can complement for DUS diagnosis in small arteries and detection of collaterals. Angiography is also recommended in patients with prognosis of intervention [7]. Therefore, our study was conducted to assess the diagnosis value of DUS and the complementary value of Digital Subtraction Angiography (DSA) in type 2 diabetic PAD of lower extremity.

## MATERIAL AND METHODS

Cross-sectional study with 40 patients diagnosed with PAD of lower limbs and Type 2 diabetes mellitus (T2DM). After taking patient history of illness, all patients were examined with DUS with or without angiography/DSA of lower limbs. The inclusion criteria were (1) T2DM diagnosed according to 2021 American Diabetes Association (ADA) guidelines, (2) Ankle-brachial index (ABI) ≤ 0.9, (3) Patients had DUS and/or supplemented angiography/DSA. Exlusion criteria included (1) traumatic injury of lower limbs arteries, (2) history of interventional or surgical procedures of lower extremity arteries.

The DUS assessement was performed with Samsung HS70A ultrasound machine (Samsung Healthcare, Korea). The examination included arteries of both lower limbes, beginning from femoral ateries down to ankle arteries. Pulse wave mode, Color mode with conventional 2D mode were used in the exam. Doppler parameters were adjust based on patients' status and arteries. The lower limbs were divided into 6 segments each including femoral artery, deep femoral artery, popliteal artery, anterior tibial artery, posterior tibial artery and peroneal artery. Stenosis and occlusion were noted with degree of stenosis by Jager criteria [5]. Besides, plaque ultrasound characteristics were also documented. DSA assessment of the corresponding segments were used for comparison with DUS and calculated the diagnosis value. The collaterals were also documented on angiography and DUS. The angiography was performed by DSA machine Allengers HF 59R (India). Retrograde puncture of femoral artery was performed to assess the contralateral limbs' arteries and pelvic arteries or aorta if indicated. Run-off of lower limbs was done after injection of iodinated contrast agent through diagnostic catheter. Images was acquired and stenosis was calculated on workstation program.

## RESULTS

Our study had 40 patients with age from 45 to 95 years old, with 26 male and 14 female patients. Mean age was 69±13; the group age of 60-80 had the highest prevalence of 47.5%. In terms of risk factor, smoking had the highest percentage of 67.5%. In our study, there was 55% of patients with more than two risk factors. Most of patients (68.6%) were at stage IV of Leriche and Fontaine staging system, following by stage III (22.9%) and stage IIb (8,6%).

*DUS characteristics and related factors*

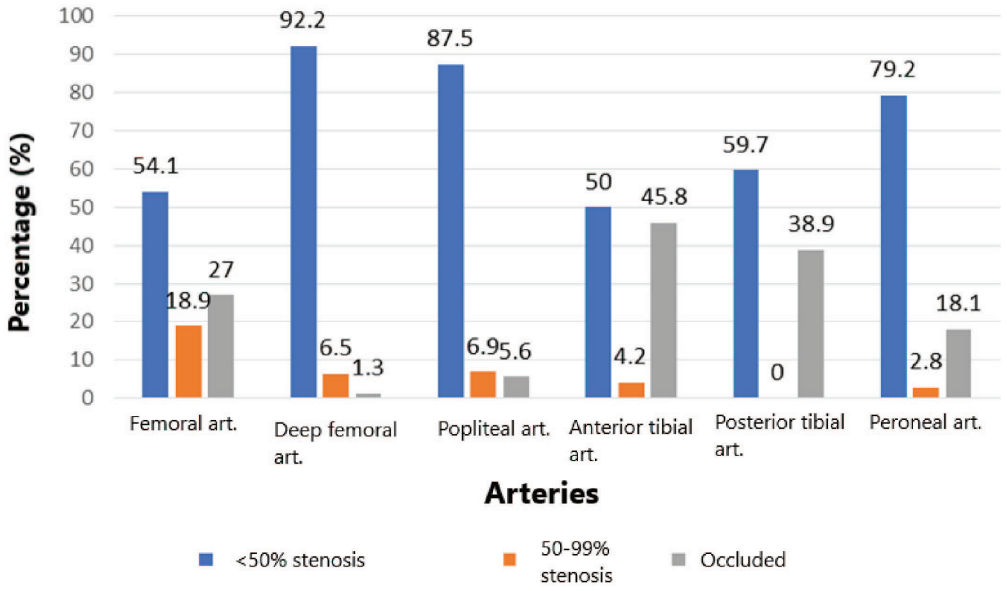


**Figure 1. Percentage of lesions in each segment**

The occlusion rate was highest in the anterior tibial artery with 45.8%, the rate of >50% stenosis was highest in femoral artery with 18.9%. After assessment of 51 plaques, hypoechoic plaques had the highest percentage of 56.9%. Unstable plaques had high percentage with 37.3% heterogeneous plaque, 43.1% irregular border plaque.

**Table 1. Correlation between arterial lesions on DUS with HbA1C**

| HbA1c (%) | Stenosis <50% | | Stenosis ≥50% or occlusion | | p |
|---|---|---|---|---|---|
| | n | % | n | % | |
| ≥ 7 | 2 | 6,5 | 29 | 93,5 | <0,05 |
| < 7 | 3 | 75,0 | 1 | 25,0 | |
| Mean ± SD | 7,24 ± 0,91 | | 10,45 ± 2,21 | | < 0,05 |

HbA1c and severity of PAD had significant correlation with p<0,05. Mean HbA1c increased in PAD with ≥≥ 50% stenosis or complete occlusion.

**Table 2. Correlation between arterial lesions on DUS with ABI**

| ABI | Stenosis <50% | | Stenosis ≥50% or occlusion | | p |
|---|---|---|---|---|---|
| | n | % | n | % | |
| <0.5 | 0 | 0,0 | 1 | 100,0 | <0,05 |
| 0.5-0.8 | 1 | 4,3 | 22 | 95,7 | |
| 0.8-0.9 | 4 | 36,4 | 7 | 63,6 | |

Arterial lesions with ≥≥ 50% stenosis or occlusion was associated with moderate to severe PAD according to ABI (95,7% and 100,0%) with p<0,05.

*The diagnosis value of DUS in PAD of lower limbs compared to DSA*

The diagnosis value of DUS was assessed with the sensitivity value, specificity value, positive predictive value, negative predictive value and the kappa index in comparison with DSA results.

**Table 3. The diagnosis value of DUS in PAD of lower limbs**

| | Sensitivity | Specificity | Positive predictive value | Negative predictive value | Kappa index |
|---|---|---|---|---|---|
| Femoral artery | 87.88% | 92.86% | 93.55% | 86.67 % | 0,71 |
| Deep femoral artery | 71.43% | 98.04% | 83.33% | 96.15% | 0,74 |
| Popliteal artery | 83.33% | 92.59% | 55.56% | 98.04% | 0,49 |
| Anterior tibial artery | 81.25% | 82.61% | 86.67% | 76.00% | 0,49 |
| Posterior tibial artery | 84.62% | 87.10% | 84.62% | 87.10% | 0,66 |
| Peroneal artery | 65.0% | 97.22% | 92.86% | 83.33% | 0,69 |
| Lower extremity arteries | 80.65% | 92.83% | 86.21% | 89.61% | 0,68 |

*The complementary value of DSA in the diagnosis of PAD*

In the total of 347 artery segments assessed in ultrasound, 22 segments were diagnosed with <50% stenosis on DUS but DSA revealed a >50% stenosis. The complementary value of DSA for DUS is highest in peroneal artery and anterior tibial artery with 2% and 1.7% of cases respectively.

In the total of 347 artery segments assessed in ultrasound, 19 segments were diagnosed with total occlusion on DUS but DSA revealed small flow in those segments and diagnosed with >90% stenosis. The complementary value of DSA for DUS is highest in the anterior tibial artery with 2% of cases.

In the diagnosis of collaterals, DUS had the sensitivity, specificity, positive predictive value and negative predictive value of 20%, 92.59%, 77.78% and 47.17% respectively. DUS had low agreement degree with DSA with Kappa value of 0.16. 75.7% of collaterals was missed on DUS and discovered on DSA. The complementary diagnosis of DSA is highest at femoral artery with 27% of additional cases.

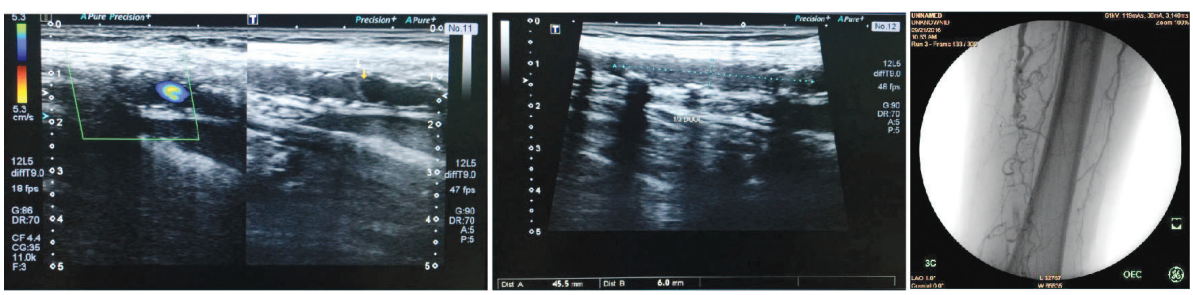

**Figure 2. 79-year-old male patient with DUS and DSA images. Complete occlusion of femoral artery with multiple collaterals not detected on DUS.**

## DISCUSSION

Diabetes causes PAD with a multifactorial pathway. The mainstay of physiopathological process is atherosclerotic injury with plaques and calcification formation that narrow vessel lumen. This is a progressive disease which subsequently leads to total occlusion of affected arteries and ischemic injury to the involved area. Therefore, the duration of diabetes correlates well with severity of PAD. Furthermore, most of patients with PAD had poor glycemia control which was documented through high HbA1c. In our study, mean HbA1c on admission was 9,99 ± 2,36 with 85,7% of patients had HbA1c > 7%. This was explained by low compliance to diabetic treatment and long-standing disease progression.

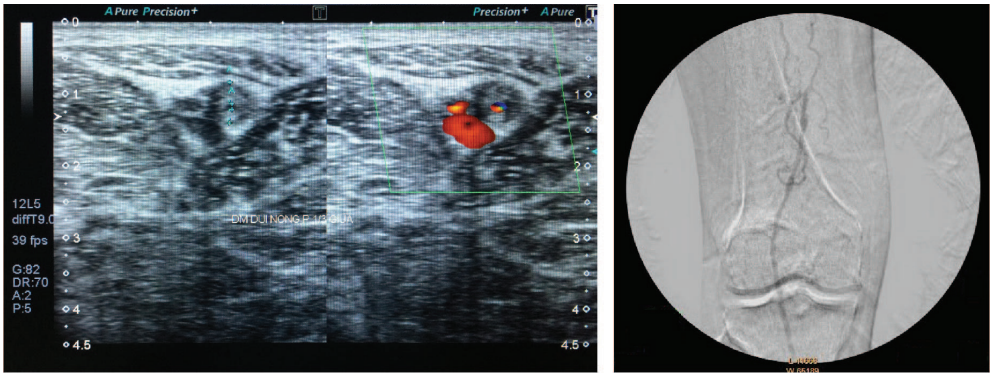

**Figure 3. 59-year-old male patient with DUS and DSA correlation. Femoral artery stenosis of >90% on DUS. DSA revealed complete occlusion of this segment.**

*The diagnosis value of DUS in PAD of lower limbs*

DUS had high diagnosis value for PAD in femoral-popliteal segments. In below-knee arteries, our study showed low agreement between DUS and DSA in the diagnosis of PAD, Kappa value was 0.49-0.69. The study of Chidambaram et al. and Koelemay et al. also showed low sensitivity and specificity of DUS in the diagnosis of PAD of below-knee arteries [1], [3]. These are small arteries and total assessment of them were limited in obese patients. An additional imaging modality was required for diagnosis at these segments.

*The complementary value of DSA for DUS*

In spite of being a non-invasive method, DUS had many limitations at distal artery segments of the calf and foot [6], DSA could be an effective modality to complement DUS diagnosis and perform intervention in appropriate cases. DSA also corrected DUS diagnosis of <50% stenosis and totally occlusive arteries. These complemented diagnoses could change the management and prognosis of patients.

Collaterals are new-grown from upstream arteries that provide blood for stenosed or occluded arteries [4]. These are important findings in the diagnosis of PAD. DSA could complement for the diagnosis of collaterals that were missed on DUS at difficult sites.

## CONCLUSION

- Severe PAD was associated with long-standing Type 2 diabetes mellitus, high HbA1c.

- Doppler ultrasound had high diagnosis value in type 2 diabetic PAD of lower extremity with sensitivity, specificity of 80.65% and 92.83% respectively.

- DSA had complementary value for DUS in the diagnosis of PAD in below-knee arteries and collaterals detection.

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