Role of Arterial Doppler in Management of Diabetic Foot

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Abstract: Background: Diabetes is a worldwide problem. Diabetic foot patients required early diagnosis and proper management. So Arterial Doppler- its relevance and validity requires to be assesed in present modern era of advanced Non Invasive techniques. Aim: To assess the role of colour Doppler in management of diabetic foot. Methodology: The study is carried out on in patients admitted in municipal general hospitals of Ahmedabad .50 patients were observed and data were collected in the prescribed proforma consisting details of patient's history ,clinical findings , laboratory and radiological investigation, arterial colour Doppler study, surgery details, complications and postoperative observation. Results: Observation and analysis of the data of present series was interesting and important aspects were compared with standard series. Peak Systolic Velocity ratio and Percentage of plaque formation in Colour Doppler of the diabetic patients are important parameters for determining the line of management , whether surgical intervention is required or not in particular individual. Conclusion: Doppler ultrasound being a non-invasive and easily repeatable procedure A normal Doppler study virtually rules out a haemodynamically significant lesion and helps to prevent unnecessary intervention. [Sameer P NJIRM 2017; 8(3):62-67]

Key words: Arterial Doppler, Diabetic foot

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Introduction: Diabetes is a worldwide problem. A majority of diabetes patients develop foot ulcers at one point of time or other during the course of their illness. A significant number of such patients will require long-term hospital treatment and amputations. Pryce described "a case of a perforating ulcer in diabetes and atactic symptoms" as early as 1887. [1]

In the first half of this century, foot lesions in diabetics, which frequently lead to amputation, were considered an unavoidable complication of diabetes associated with arteriosclerosis and were classed under the heading of "diabetic gangrene.[2]

It was not until the 1950s that diabetic neuropathy, ischemia and infection , were finally recognised as precondition of foot complications in diabetics- fact that still hold good today. The good prognosis for local surgery in neuropathic lesions and the confinement of radical surgical interventions to ischemic changes was also described first at that time[3].

Definition of diabetic foot:Foot of the diabetic patients that have pathological consequences, including infection, ulceration, and/or destruction of deep tissues associated with neurological abnormalities and various degree of peripheral vascular disease in lower limb.

Foot infections are a major source of morbidity and a leading cause of prolonged hospitalization for persons with diabetes.

Diabetes is one of the major problems of modern generation worldwide. According to Modi et al., overall incidence of diabetes in india is 1.2%[4]. The death rate in each year due to its complications is 2.1% in urban& 1.5% in rural, usually common in age group of 40-60years affecting both genders equally . The complications are more prevalent among the people of lower Socio-economical status due to negligence, illiteracy and poverty.

Ultrasonic imaging provides a non-invasive assessment of the arterial circulation in the lower limb and is accepted as a valuable diagnostic technique. Grey scale images identify plaque and thrombus, duplex assessment provides a measurement of blood velocity through a vessel, and Colour Doppler imaging enables the rapid localization of arterial stenosis and occlusions.

It thus allows the evaluation, the quatification and the follow up of the arterial diseases by carrying out a precise vascular mapping. Colour Doppler imaging is safe, popular, cost-effective, repeatable, non-invasive procedure for evaluating lower limb arteries.

Aims of the study are: The aims of the study are to analyze the data obtained from patients having

diabetic foot in form of (1) Study of basic etio-pathology.(2) To analyse the role of colour Doppler in diagnosis of diabetic arteriopathy. (3) To assess the role of colour Doppler in management of diabetic foot. (4) To review the outcome of various management modalities of diabetic foot. (5) To learn about overall progress of the patient. The study and conclusions are important in the sense of assessing various aspects of this Newer procedure in context of present time.

Method: 50 patients of having diabetic foot admitted in one of the municipal general hospitals of Ahmedabad city, India, were studied during period of two years, i.e. from November 2014 to October 2016 for diabetic foot. All cases were studied according to general proforma, which included clinical details about symptoms, signs, laboratory and radiological investigation, arterial colour Doppler study, surgery details, complications and postoperative observation.
Risk factors of diabetic foot are: peripheral neuropathy [5] , peripheral vascular disease, limited joint motility, foot deformities, minor trauma, impaired visual acuity, uncontrolled hyperglycemia, cigarette smoking, impaired immunological responses. It has been recognized that persons with diabetes are prone to foot problems. Recent advances in molecular biology have added substantial insight into Pathophysiology of the disease and openednew avenues for treatment.[6]

Neuropathy and Ischemia are the 2 important predisposing factors for the formation of diabetic ulcer.

Wagner Diabetic Foot Lesion Grading System: Wagner (1983) grades lesions of diabetic foot from 0-5 by depth and extent.

Grade Description

0. No ulcer but high risk foot
1. Superficial ulcer(commonest site is Head of 1st metatarsal)
2. Deep ulcer with no bony involvement
3. Abscess with bony involvement
4. Localized gangrene
5. Gangrene of whole foot

Doppler effect:[7] The Doppler effects is a change in the frequency of a detected wave ,when the source or the detector ismoving. In medical ultrasonography, a Doppler shift occurs when reflectors move relative to the transducer. The Doppler shift frequency ,or simply the Doppler frequency, is the differencebetween the received and transmitted frequencies.

Ultrasonic Doppler equipment is for detecting and evaluating bloodflow. In ultrasonography ,transducers convert electrical energy into mechanical energy to produce ultrasound and vice versa.

Five types of diagnostic Doppler instruments are usually distinguished:[8] (1) Continuous Wave (CW) Doppler (2) Pulsed Wave (Pw) Doppler (3) Colour Doppler Imaging (Cdi, Colour Velocity Imaging) (4) Duplex Doppler (5) Power Doppler Imaging. Velocity criteria for the assessment of lower limb stenosis[9]

Percentage Stenosis	Peak systolic velocity (ms-1)	Velocity ratio
Normal	<1.5	<1.5: 1
0-49	1.5-2.0	1.5-2: 1
50-75	2.0-4.0	2-4: 1
>75	>4.0	>4: 1
Occlusion	----	---

Duplex imaging has been compared with lower extremity arteriography to define its accuracy. These studies demonstrated a sensitivity of 77% to 92% and a specificity of 92% to 98% for correctly categorizing a stenosis as greater or less than 50% diameter reduction. These reports evaluated the capabilities of duplex imaging in the proximal vessels, but there is limited information about its sensitivity in the calf arteries.

All studies reported high negative predictive value(87% to 98%), indicating that significant occlusive arterial disease can be excluded in patients with normal duplex imaging examination.

Results: In current study, shows that diabetic foot lesions are common in middle aged person i.e. in 4th& 5th decade of life. Study shows 35 patients(70%) out of 50 patients were in middle age group between 41 to 60 years of life.

Table 1: Age group of diabetic foot patients

Age	No. of Patients	Percentage (%)
41-50	16	32
51-60	19	38
61-70	13	26
>70	2	4
TOTAL	50	100

It is well accepted fact that the lower extremity arterial disease is the disease of middle age groups as cited by Cossman et al[10] , Hughson et al[11].
Study shows 36 patients(72%) out of 50 patients were male. In a study by Somson griffin[12] of 100 patients - 62 no. of patients were male. In another study at Sri Adichunchanagiri hospital & research centre[13] of 50 patients -37 no. of patients were male. Dr.Kavithaet al[14] also had majority of patients who were males comprising of 76%.

Study showed that out of 50 patients, 16 patients presented with cellulitis which is the most common lesion encountered followed by ulcer(13 patients) , gangrene(12 patients) and abscess(9 patients).

Table 2: According to duration of diabetic status

Duration in years	No of patients	Percentage(%)
Newly detected	11	22%
<1 yr	1	2%
1-10yrs	27	54%
11-20yrs	10	20%
>20yrs	1	2%
Total	50	100

Study shows 39 patients(78%) were known case of diabetes presented with foot lesion and 11 patients (22%) were newly detected case of diabetes presented with foot lesion.

Study shows 27 patients (54%) presented with diabetic foot lesion were having 1-10years of duration of diabetes. In a study at, Sri Adichunchanagiri Hospital & research centre[13] – 20 patients out of 50 had diabetes of 1-10year duration

According to trauma to foot: Study shows 29 no. of patients(58%) out of 50 patients revealed a history of some kind of trama before the onset of the lesion. In a study at Sri Adichunchanagiri Hospital & Research centre[13], 34 cases out of 50 had history of trauma before the onset of the lesion.

According to smoking habit: Study shows that out of 50 patients, 25patients(50%)had habit of smoking. Out of 14 female patients none had habit of smoking.
In our study both limbs were equally affected. Slight higher involvement seen in right limb(54%).

According to joint lesion: In the study 4 patients had joint/bony lesion. 3 patients had erosion of terminal phalynx with wide interphalangeal joint space. 1 patient had great toe previously amputed. All 4 patients had abnormal arterial Doppler findings.
According to Wagners grading system for diabetic foot: In the study majority of patients were in Grade-2 with 44%, Grade 1, 3, 4, 5 had 22%, 8%, 16% , 10% respectively.

Most common organism isolated from septic lesions of the diabetic patients was staphylococcus aureus. Anaerobes were uncommon. Infection was more pronounced in patients who had abnormal arterial Doppler findings.

Study shows 15 patients(30%) out of 50 had infective lesion all had normal arterial Doppler study. Pure vascular lesions found in 2 patients both had either blackened toes or foot underwent major or minor amputations. Mixed lesion (Vascular+Infective+Neurogenic) were found in 33 patients(66%) indicating all components play a role in diabetic foot lesion.

Table 3: Site of lesion by Colour Doppler

Level	No of patients	Percentage (%)
SFA	9	25.7
DFA	3	8.5
PA	7	20.2
PTA	3	8.5
ATA	4	11.4
DPA	9	25.7

Out of 50, 35 patients had abnormal Doppler findings. The level of lesions as occlusion/stenosis in the lower limb is given in above table and the maximum lesions were found in superficial femoral arteries and dorsalis pedis arteries followed by popliteal arteries.

Among the Atheromatous plaque patients 8 (22.8%) had 1-19% stenosis , 6(17.1%)had 20-49% stenosis , 11(31.4%) had 50-99% stenosis, and 10(28.5%) had total occlusion-out of 35 patients.

Among all 35 patients ,14 patients(40%) had PSV ratio(peak systolic velocity) <2:1, 8 patients(22.8%)had PSV ratio between 2-4:1, 3 patients(8.5%)had >4:1 and 10patients (28.5%)had total block. According to Cossman et al[10] PSV ratio of >2 are indicative of haemodyamically significant stenosis i.e. >50-75% stenosis, and PSV ratio of >4 have >75-99% of stenosis. Among the patients who

had haemodyamically significant stenosis, most of the lesions were found in femoropopliteal segment.

Table 4: According to Arterial Doppler findings

Arterial Doppler	No of patients	Percentage (%)
Normal	15	30
Generalized athero. narrowing alone	25	50
Generalized athero. narrowing+ arterial block	10	20
Total	50	100

Study shows 10 patients (20%) had block- occlusion in aterial circulation with clinically absent pulsation, 25 patients (50%) had generalized atherosclerotic narrowig with clinically present or feeble pulsation, and normal arterial Doppler was present in 15 patients (30%) presented with diabetic foot lesions.

Study shows that amputation was necessary in 13 patients, of which 3 patients had only generalized atherosclerotic narrowing and 10 patients had generalized atherosclerotic narrowing with block.
All 13 patients had serum triglyceride level more than 251 mg/dl.

Apart from medical treatment: conservative approach results in healing of diabetic foot lesion in 7 patients (14%). Incision& drainage was required in 10 patients (20%). Debridement alone was done in 14 patients out of 50, followed by 6 patients that required Split thickness graft to achieve healing ofbig open wound and in 8patients wound healed secondarily. Debridement and amputation were required in 7 patients, single or multiple toes amputation and/or major amputation. 6 patients had amputation primarily.

Table 5: According to arterial Doppler and amputation

Block in arterial Doppler	Amputation
Present	10
Absent	3
Total	13

Study shows that 10 patients had arterial block and 3 patients did not had block in arterial Doppler study (having other etiology playing role) -all had amputation. All the patients with abnormal arterial Doppler findings were started on lifelong antiplatelet with hypolipidemic drugs and vasodilator.

13 patients who had Generalized Atherosclerotic Narrowing with significant stenosis underwent major or minor amputation and are on lifelong drug therapy. 2 patients who had Generalized Atherosclerotic Narrowing with significant stenosis in Superficial femoral artery underwent femoro-popliteal bypass surgery after 8 weeks of treatment of diabetic foot.

Discussion: The concept of diabetic foot syndrome incorporates various clinical pictures characterized by different etiologies and pathological mechanisms. Common to all is the fact that injuries to the foot of diabetic patient can results in complication that may lead to amputation of the limb if treatment is delayed or ineffective.

Diabetic foot lesions are common in middle aged person i.e. in 4^{th}& 5^{th} decade of life-, this may be attributed to many factors like duration of diabetes, history of addiction to smoking or alcohol and hyperlipidemia along with hyperglycemia which together accelerates the process of plaque formation in arteries of lower extremities.

Higher incidence of diabetic foot lesion are found In male is attributed to smoking, trauma, and unhygenic habits. As males are the breadwinners of the family and are mostly working out door ,which makes them more vulnerable for trauma and sequelae.

Most of the patients were having diabetes of long duration, have higher chances of developing foot lesions.

Most of the patients presented with history of some kind of injury to the foot before the onset of the lesion, because in long standing diabetes there is neuropathy which results in loss of sensation and the patient will be unaware of the injury and neglects it.

Figure 1: Diabetic foot abscess & Gangrene

Most common organism isolated in culture was Staphylococcus aureus(48%). aerobic pathogen in diabetic foot infection are chiefly Gram -positive cocci. If diabetic ulcers including those infections not requiring amputation are examined early, staphylococcus aureus emerges as the primary pathogen.

Cellulitis was the most common presenting lesion (30%). Majority of the patients had positive history of smoking (50%).

In our study 24% of patients presented with gangrene which was very low as compared to other studies probably because number of patients included in our study were less, better control of glycemia and infection and timely dressing prevented diabetic foot progression to gangrene.

The amputation rate is much lower as compared to other studies, due to better education of the patient, better glycemic control , proper care of foot, proper use of antibiotics, extensive debridement and regular dressing. Hyperlipidemia in diabetic foot patients accelerate the process of formation of atheromatous plaque in intima media of the arteries. Thus along with good glycemic control hyperlipidemia should also be under control to minimise diabetic foot complication and hazards of amputations.
Duplex sonography can be used to classify peripheral arterial disease into haemodyanamically non-significant and significant using peak systolic velocity. Peak systolic velocity ratios and spectral waveforms which will help in management.

PSV ratio and Percentage of plaque formation in colour Doppler of the diabetic patients are important parameters for determining the line of management[15] , whether surgical intervention is required or not in particular individual.

Doppler ultrasound being a non-invasive and easily repeatable procedure, it can be used for postoperative screening and in assessing the progression of disease over duration of time.

Management of diabetic foot patients: Control of diabetics: strict anti-diabetic diets, regular exercise, oral anti-diabetic agents, and insulin treatment .

Foot care of patients- To instruct patientabout Do's& Don'ts of foot care protocol.

Dressing and debridement of infective lesions. : For vascular lesion: exercise, cessation of smoking, vasodilator drugs, lumbar sympathectomy, vascular reconstuctive surgery, amputation.

For neuropathic ulcer: callus removal, rest of ulcer y immobilization, by contact plaster cast, platelet derived growth factors , dressing with human dermal replacement.

Conclusion: Middle aged person are associated with increase risk of peripheral arterial atherosclerotic disease associated with diabetes. With increase in duration of disease and repeated episodes of hyperglycemia- the incidence of peripheral neuropathy increases and renders the patient to unrecognized injury, which potentiates the risk of bacterial invasion and infection.

Duplex sonography can accurately locate the site and extent of stenosis/ occlusion. Low cost, non invasive nature , outpatient procedure and less time required to make Doppler sonography. Doppler ultrasound being a non-invasive and easily repeatable procedure- A normal Doppler study virtually rules out a haemodynamically significant lesion and helps to prevent unnecessary intervention.

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