Imaging in Type 2 Diabetes Mellitus

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ABSTRACT

Since India will see a significant rise in patients with Type 2 Diabetes Mellitus over next three decades, imaging modalities will have an important place in monitoring, detection of complications , and management of the associated medical conditions. Imaging modalities for monitoring of Type 2 DM (Continuous glucose monitoring systems, flash glucose profiles) are useful to detect glycemic variability, undetected hypoglycaemia, hypoglycaemiaun awareness. They are useful for titration of antidiabetic medications, They also serve as excellent motivational tools. Biothesiometer, dopplers, pressure plate systems, fundus camera are very useful bedside imaging modalities for the diagnosis of complications of type 2 DM. The other conventional imaging modalities like X-ray, ultrasound, computed tomography, magnetic resonance imaging are useful for the demonstration of the particular findings seen in patient with type 2DM.They are also required whenever there is need to rule out secondary diabetes.

Key-words : Imaging , Type 2 DM, Diabetic retinopathy, Diabetic neuropathy, Planter pressure analysis

Introduction :

According to International Diabetes Federation (IDF) 2017 Atlas, the worldwide prevalence of diabetes mellitus (DM) will increase from 424.9 million in 2017 to 628.6 millions in 2045[1]. The majority of increase will be in type 2 DM .Imaging modalities have very important place in the management of type 2 DM and in detection of its complications. They are also required for managing medical conditions associated with DM. The imaging modalities can be specific i.e. used mainly in patients with DM or modalities used in general. This review will cover the imaging modalities under following heads.

- Imaging specific to Diabetes Mellitus (DM)
- Imaging not specific to DM, but typical findings may be seen in DM
- Imaging to rule out secondary diabetes

Imaging specific to Diabetes Mellitus

1. Imaging used for monitoring in type 2 DM

- Continuous Glucose monitoring system (CGMS)

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Received on 18th May 2018 Accepted on 20th June 2018

CGM (iProMedtronic, sensor and recorder) is a way to measure glucose levels throughout the day and night. A tiny electrode called a glucose sensor is inserted under the skin to measure glucose levels in tissue fluid. It is kept for around five days, then removed and attached to a computer to get the blood glucose profiles[2]. The disadvantages are the high cost ,requirement of finger prick calibration and the data is retrospective. CGM with newer insulin pumps gives real time blood glucose levels.

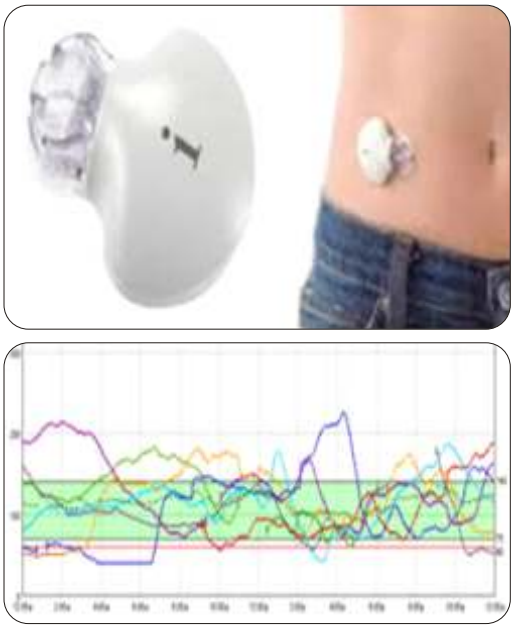

Figure 1 : **TheiPro unit and the Graph of blood glucose levels (each color represents**

- Ambulatory/Flash glucose profile (FGP)

The Flash Glucose Monitoring System (Freestyle / Libre Abbott) consists of a small, round sensor. It is water-resistant and disposable. It is applied on the back of the upper arm. The sensor has a self-adhesive pad and stays in place for 14 days. Patient interaction with the sensor or finger-prick calibration is not required. The system continuously measures glucose in interstitial fluid through a small (5 mm long, 0.4 mm wide) filament that is inserted just under the skin. It records glucose levels every 15 minutes, capturing up to 1,340 glucose readings over two weeks. The data picked up by the sensor is read by using a reader, which looks like a mobile phone[3]. The reader is attached to a PC to get the blood glucose profiles.

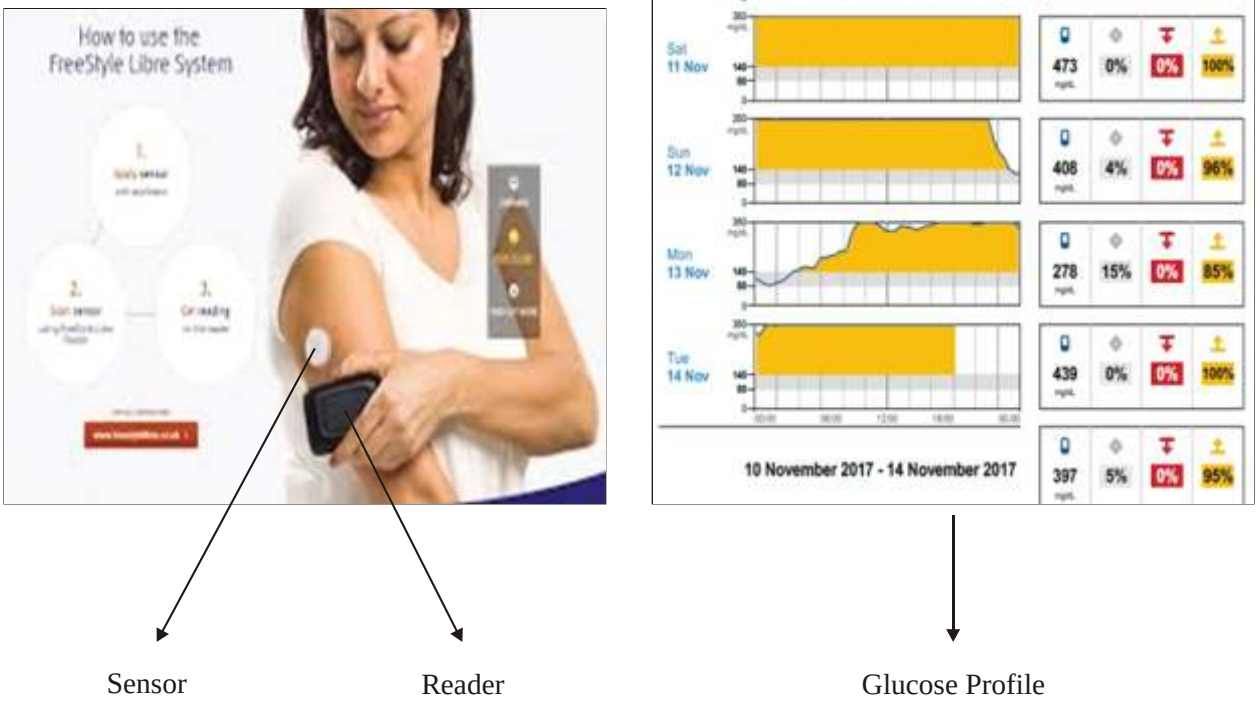

Figure 2 : **Ambulatory / Flash glucose profile (FGP)**

1. Bedside Imaging used to detect complications of type 2 DM

- Fundus examination (Eyes)

Diabetic retinopathy (DR) is seen in 21.7% patients with Type 2 DM in India[4]. It is classified broadly into nonproliferative DR and proliferative DR (ETDRS classification)[5]. Macular edema can occur with either. Three imaging modalities are mainly used for detection and monitoring the course of DR. They are fundus photograph, optical coherence tomography (OCT) and fluorescein angiography. There are various fundus cameras ranging from 40 degrees (used for screening) to 200 degrees (used for detailed fundus examination).

OCT is non-invasive modality used for full thickness retinal imaging, very sensitive for detection of macular edema[6]. It is also useful in monitoring the regression of macular edema after treatment.

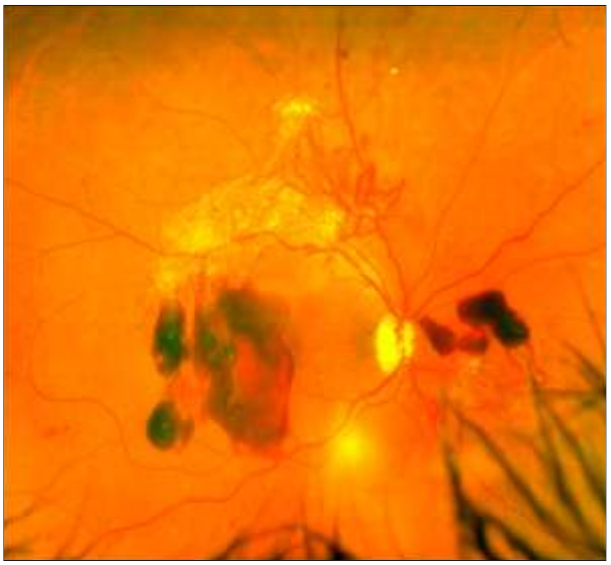

Figure 3 : **Wide-field Fundus image showing Neovascularization & Pre-Retinal haemorrhages.**

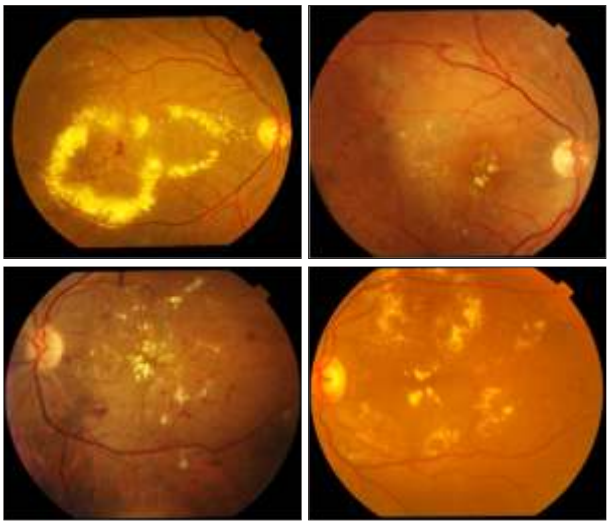

Figure 4 : **Fundus imaging showing Various presentations of focal & diffuse diabetic maculopathy**

- VPT estimation (Nerves Large fibre)

Diabetic neuropathy (DN) affects around 30 - 50 % of type 2 diabetic patients in India.[7,8,9]. Distal symmetrical sensorimotor (SM) polyneuropathy and autonomic neuropathy are two predominant forms of DN. Careful and meticulous clinical examination can diagnose DN[10]. SM neuropathy causes intrinsic muscle atrophy leading to foot

Figure 5 : **Ultra-wide-field Fluorescein angiography showing - extensive capillary non-perfusion areas & leakages of dye-S/O Proliferative Diabetic**

Figure 6 : **Serial Oct images showing response to Anti-VEGF injection in Diabetic Macular Oedema**

deformity, decreased joint mobility, and loss of protective sensations. Autonomic neuropathy leads to dry feet and fissure formation. All these are risk

for high plantar pressure diabetic foot ulcer. Vibration perception threshold (VPT) estimation detects large myelinatedfibre neuropathy. Biothesiometer measures the VPT quantitatively. Risk of ulceration is more if the VPT values (measured on the plantar aspects of the foot) more than 25 v as compared to values < 15 V.[11]

The biothesiometer is usually connected to a PC, on which the VPT values can be seen.

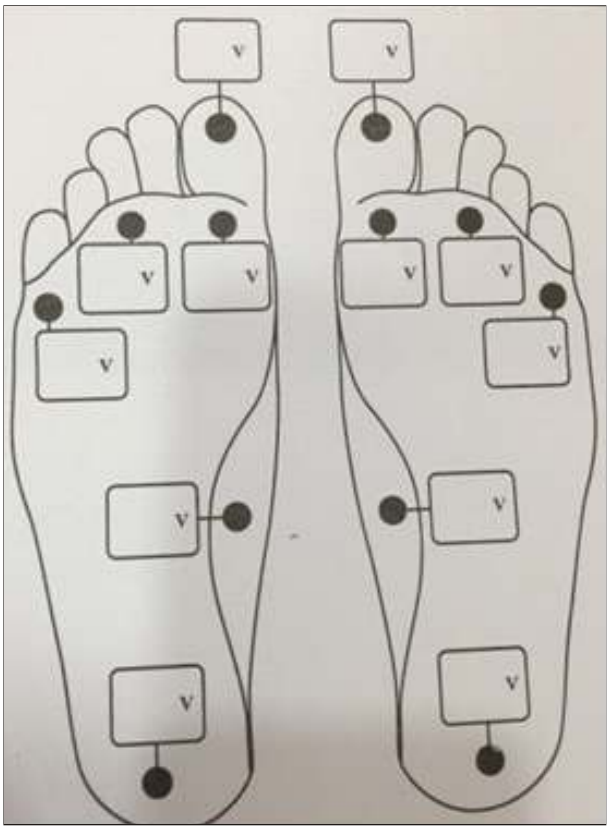

Figure 7 : **The points on plantar aspect of the feet where VPT is measured**

- ABI estimation / doppler (Peripheral vessels)

Ankle brachial index and toe brachial index can be calculated by bedside automatic, automated six ports / twelve ports Doppler. Though expensive, it has advantage of calculating TBI (Toe Brachial Index), overhand held doppler. Also bedside penile doppler can be done. Wave forms are seen on PC screen. Thenormaltriphasic doppler arterial wave has an initial peak, representing systole. The second portion, dipping down, indicates the reverse flow in early diastole. The third portion, a small peak, signifies the forward flow of late diastole. Biphasic or monophasic forms are the abnormal waveforms and indicate stenoses or slow flow[12]. ABI of 1.0-1.2 is considered the normal range; ABI of more than 1.2 suggests abnormal vessel hardening from peripheral vascular disease. ABI of less than 0.9 suggests arterial disease, while less than 0.5 warrants urgent attention.

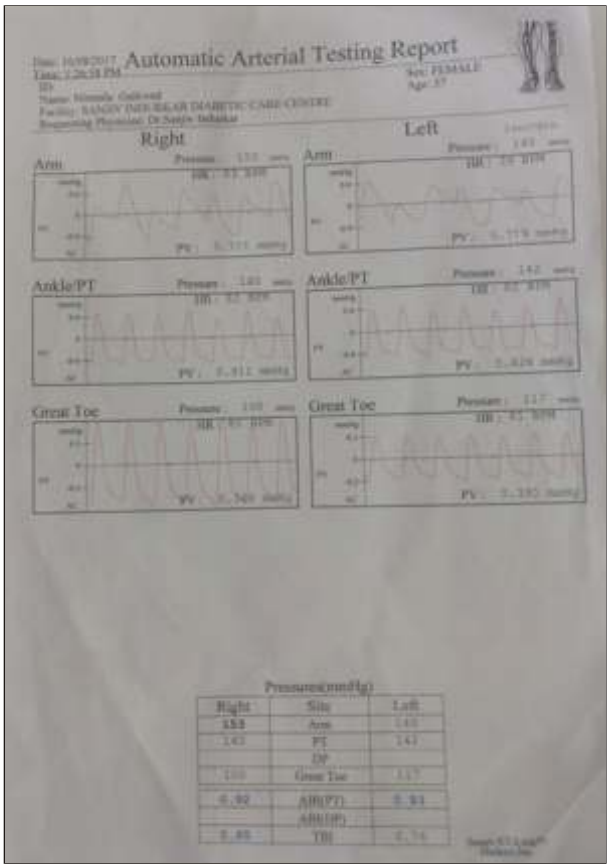

Figure 8 : **Bedside six port Doppler report showing waves with calculated ABI and TBI**

- Podiascan (Plantar pressure analysis)

Various footpressure mapping systems are available for measurement of plantar foot pressure. In shoe and platform methods are used commonly for measuring plantar foot pressure. They use capacitive, resistive, piezoelectric, piezoresistive sensors[13]. They are calibrated every examination by using patient's height and weight.

Plantar pressure plate analysis detects the abnormal pressure points on the plantar aspect of the foot which are at risk of ulceration. Fawzyet. Al. suggested cut-point of 355 kPa for FFPPP (forefoot peak planter pressure) to denote high risk for ulceration to be used along with other contributory risk factors such as duration of diabetes, smoking, glycemic load, foot deformity, and severity of neuropathy[14]. Preventive footwear to redistribute the plantar pressure can be advised with the help of podiascan. It is also helpful in detection of early midfoot collapse, gait abnormalities.

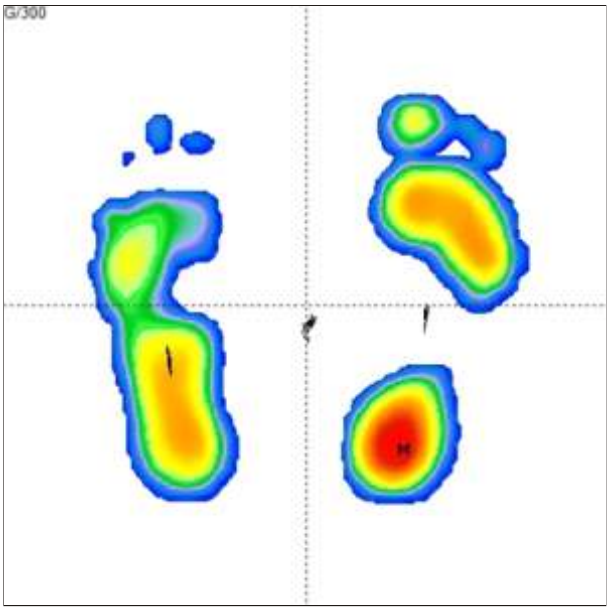

Figure 9 : **Podiascan image of left midfoot collapse with high pressure area in red on right heel**

Imaging not specific to DM

1. Kidney / Bladder

Hypertrophied kidneys due to hyperfiltration are see in early years of DM. As the nephropathy progresses, chronic small sized atrophic kidneys are observed in the late stages[12].

● Emphysematous pyelonephritis - It is a rare necrotising infection of the renal parenchyma and peri renal tissues charecterized by gas formation in the same. Over 90% cases occur in diabetic patients. In the presence of hyperglycemia and ischaemic

Figure 10 : **Hypertrophied kidney seen in type 2DM (USG)**

necrosis, E.coli, proteus and Klebsiella ferment glucose, lactate etc resultind in gas formation[15]. Abdominal radiography/ultrasound demonstrate air in the renal parenchyma. CT abdomen is the investigation of choice.

Papillary necrosis Necrosis and sloughing of the renal papillae are five times more common in diabetic than in nondiabetic patients. A ring sign is presnt on retrograde pyelogram as the seperated papilla is surronded by the contrast medium[15].CT and ultrasound is done commonly.

Figure 11 : **Emphysematous pyelonephritis (USG)**

● Significant Post void residue due to autonomic neuropathy - Urinary bladder dysfunction in diabetes is due to detrusor instability, poor bladder sensation and contraction due to neuropathy. Urodynamic evaluation is needed for diagnosis of type of bladder dysfunction and the therapeutic strategies[16].

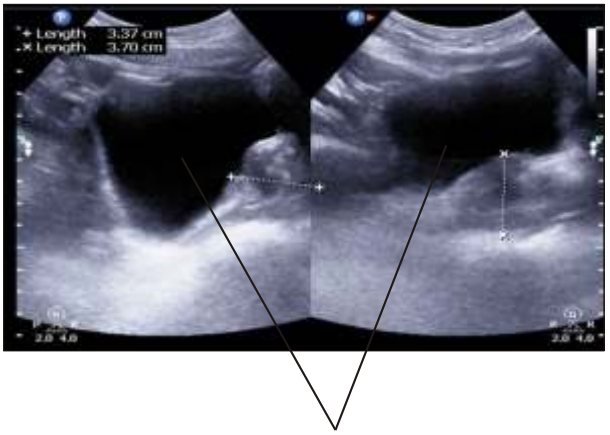

Figure 12 : **Distended bladder due to significant post void residue (USG)**

• Chronic Cystitis Commonly seen in elderly diabetic patients especially females. Thickened bladder wall is seen on ultrasound along with symptoms of UTI and significant bacteruria. E.coli common causative organism[12,15]. Cystitis may ascend upwards leading to involvement of upper urinary tract and kidney injury. It requires prophylactic antibiotic therapy frequently.

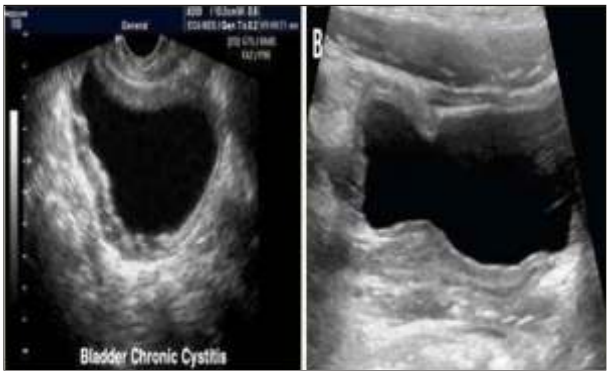

Figure 13 : **Thickened urinary bladder wall due to chronic**

2. Cardiovascular system

• Echocardiography is the commonly used initial imaging test which shows diastolic dysfunction is frequently seen in patients with type 2 DM, even in asymptomatic patients.[17]

• Coronary angiography shows involvement of small vessels in patints with type 2 DM. There is diffuse inolvement of the arteries. Chronic total occlusion is seen commonly. PTCA is difficult due to small vessel involvement. Better survival is seen after CABGS as compared to PCI in presence of multivessel disease[18].

• MRI (Magnetic resonance imaging) is used for the assessment of cardiac function and PET (Positron emission tomography) is useful for assessment of myocardial perfusion and metabolism[19].

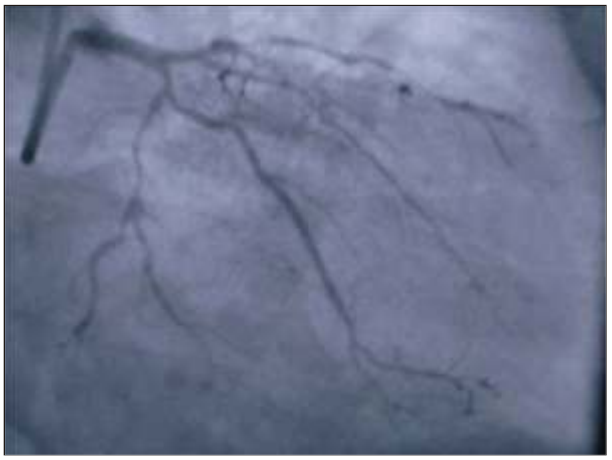

Figure 14 : **Oronary angiography showing left sided vessels with diffuse involvement**

• Vascular Calcifications - High glucose and other potential factors may cause transformation of vascular smooth muscle cells into osteoblast-like cells[15].

Medial calcification appears to be a strong independent predictor of cardiovascular mortality. The lower limb arteries frequently show chronic atherosclerotic involvemen[12].

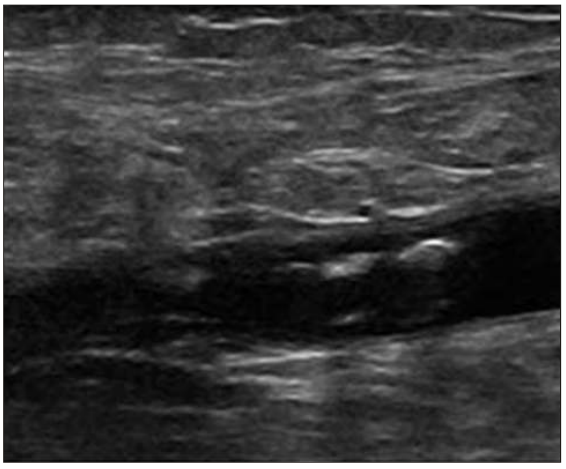

Figure 15 : **Calcification in an artery (USG)**

3. Gastrointestinal system

● Diabetic Fatty Liver Persistent uncontrolled hyperglycemia leads to glycogen deposition in the liver leading to diabetic fatty liver (steatosis). On ultrasound there is increased liver echogenicity, attenuation of the ultrasound wave, poor delineation of the intrahepatic architecture. Liver enzymes elevated. Biopsy is the gold standard. Measurement of liver stiffness by transient elastography is another noninvasive imaging modality for the evaluation of diabetic fatty liver (nonalcoholic steatohepatitis)[20].

Figure 16 : **Diabetic fatty liver (USG)**

● Gall bladder Calculi Multiple GB calculi is common finding in patients Type 2 DM. Increasing age, female gender, overweight individuals are the associations. Patient has symptoms of dyspepsia, abdominal pain[12,15].

4. Brain / ENT

● Rhinocerebral Mucor mycosis It is caused by the saprophytic fungi Rhizopus and Mucor. It has highest frequency and mortality as compared to other mucormycoses[15]. Common presentation includes, headache, nasal discharge, facial pain, swelling, fever, loss of vision, diplopia, proptosis, palatal ulcer, perinasal cellulitis nasal crusting ,necrosis of turbinates. Facial palsy, hemiplegia occur with nervous system involvement. There is inflammatory tissue infiltration adjacent to the paranasal sinuses and extension into the pterygopalatine fossa, infratemporal fossa and orbit or the cavernous sinus. Inmucormycosis the affected sinuses appear hypointense on T2 weighted & iso to hypo intense on T1 weighted images (MR)[21]. Intravenous / liposomal amphotericin B should be started till the diagnosis is confirmed histopathologically. Extensive debridement is also must.

Figure 18 : **CT scan of paranasal sinuses coronal section in 40 year diabetic female patient shows hyperdense lesions involving frontal sinuses, ethmoid air cells, and maxillary sinuses**

Destruction of frontal bone seen with intracranial extension of disease. Features suggestive of rhinocerebral mucor mycosis.

● Malignant otitis externa This potentially life threatening condition involving external auditory canal and skull occurs mainly in elderly diabetic patients. Majority of cases are caused by Psuedomonas aeruginosa. Patient presents with severe ear pain and discharge from the ear. Colonization with Aspergillus species should be considered in nonresponding cases[12]. High resolution CT Imaging (HRCT) and Magnetic resonance imaging (MRI) have been found useful in defining the anatomical extent of soft tissue involvement, bony erosion, and intracranial complications. HRCT is the initial imaging of choice as it is more accurate in delineating bony

involvement and cheaper than MR .MRI is effective in identifying soft tissue involvement and intracranial extension particularly dural enhancement[22].

5. Musculskeletal System

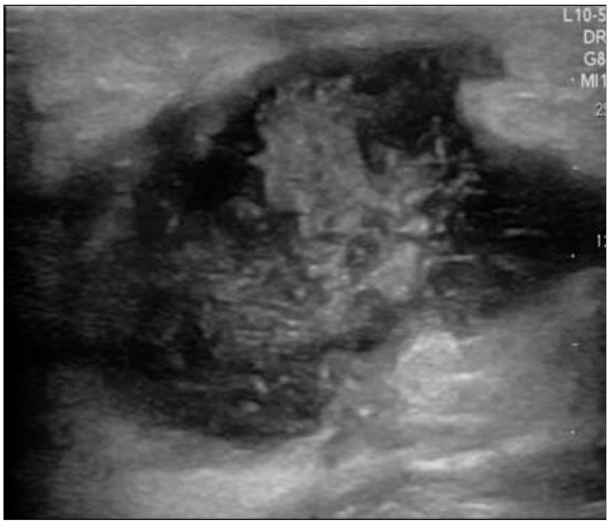

Figure 19 : **Intramuscle collection of pus (USG)**

• Infectious and Inflammatory Myositis - Because of underlying immune dysfunction, diabetic patients are at risk of infectious pyomyositis .It results from the hematogenous spread of bacteria to muscle[15].

• Charcot's foot - Characterized by varying degrees of bone and joint disorganization secondary to underlying neuropathy, repeated trauma (not realised by the patient due to severe neuropathy), and changes in bone metabolism. Weight bearing X ray of the foot will show the bone destruction[15]. MRI foot is often needed for the management. Complete offloadindg with total contact cast is required for this condition.

6. Lungs

Pulmonary tuberculosis or lung abscess should be suspected in patients with either of chronic cough, weight loss ,anorexia and very high, difficult to control blood glucose levels[12,15].

Figure 20 : **Neropathic joint destruction**

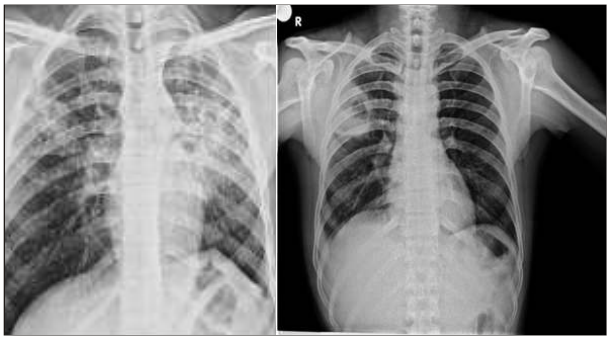

Figure 21 & 22 : **First X-ray picture showing pulmonary tuberculosis**
Second X ray picture showing right midzone lung abscess

Imaging to rule out secondary diabetes

Secondary diabetes is frequently misdiagnosed as type 2 DM , hence following causes of secondary diabetes must be suspected in patients with typical findings

1. Fibrocalculous pancreatic diabetes - Brittle insulin dependent diabetes with pancreatic calculi and fibrosis of pancreas. There is usually associated exocrine pancreatic deficiency[15].

Figure 23 : **Pancreatic Calculi**

2. Acromegaly Growth hormone secreting adenomas of anterior pituitary may cause raised blood glucose levels .Classic features of acromegaly in a diabetic patient ,MRI of the pituitary gland with IGF 1 levels, post 75 gm glucose suppression of growth hormone levels help in diagnosis[12].

3. Cushing's syndrme in diabetic patients with features of hypercortisolism, dexamethasone suppression test, serum ACTH levels will guide either to go for MRI pituitary (ACTH dependent Cushing's) or to go for CT adrenals (ACTH independent Cushing's)[12].

Conclusion :

Imaging modalities are indispensible part of management of type 2 DM. While AGP / FGP are useful tools for monitoring, fundus camera, biothesiometer, bedside dopplers, podiascan are of help for early detection of complications. Conventional radiology is also required routinely in patients with type 2 DM.

Acknowledgment :

Dr. Sanjiv Indurkar - MD (Diabetologist, Aurangabad).

Dr. Parmeshwar Kahalekar - MS (Ophthalmologist, Aurangabad).

Dr. Mahesh Deshpande - MD, DM (Cardiologist, Aurangabad).

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