Learning objectives

To recognize common and pathognomonic CT & MRI findings in Diabetes Mellitus (DM).
Background

Diabetes Mellitus (DM) is a common multi-systemic disorder affecting 8.3% of the world's adult population. Due to its vascular, neuropathic and immune system affections, it possibly affects every system in the human body, viz: brain, cranio-facial skeleton, cardiovascular, musculoskeletal, genitourinary and gastrointestinal.
Findings and procedure details

CT & MRI of patients with diabetes were retrospectively reviewed. CT scan was done on Philips Brilliance 64 slice multi-detector CT scanner and MRI on Philips Achieva 3T MRI. Common and uncommon pathologies associated with diabetes mellitus and their radiological findings are presented below in this exhibit.

1. Hyperglycemia-induced hemichorea hemiballismus syndrome (HIHH) Fig. 1

HIHH is seen in patients with poorly controlled diabetes, and patients classically present with unilateral hemichoarea and hemiballismus. On different imaging modalities, unilateral imaging abnormalities are noted in caudate nucleus and putamen, contralateral to the side of patient's symptoms. On CT they appear hyperdense on plain scan and show no enhancement. On MR T1 hyperintensity is noted, with no signal abnormality noted on T2, FLAIR, gradient echo (GRE) or DW images [1]. Various theories are promoted for the cause of T1 hyperintensity, the most commonly accepted theory is of protein hydration layer in the cytoplasm of swollen gemistocytes [2]. Other theories are of petechial hemorrhages [3] and of basal ganglia blood flow reduction. Differential diagnosis include other causes of basal ganglia T1 hyperintensity, however with typical history of unilateral choreo-atheotid movements in a diabetic patient, and characteristic imaging findings, HIHH is the only differential.

2. Non Ketotic Hyperglycemic Hyperosmolar Syndrome (HHS) (Figure 2)

Nonketotic hyperglycemic hyperosmolar syndrome is characterized by severe hyperglycemia and hyperosmolarity, with absence of ketoacidosis. It is usually observed in diabetic patients over 50 years and patients present with focal seizures, hemianopsia, and coma. CT is usually normal. On MRI, there is focal T2 and FLAIR hypointensity in subcortical white matter with no contrast enhancement. The possible reason for hypointensity is hyperglycemia induced transient focal cerebral ischemia [4]. Recognition of the association of these neurological and radiological abnormalities with HHS is important because correction of the underlying hyperglycemia will lead to rapid improvement [5].

3. Malignant Otitis Externa (Figure 3)

Malignant otitis externa (MOE) also called as necrotizing otitis externa is a severe invasive form of otitis externa caused by Pseudomonas aeruginosa and occurs most often in elderly diabetics. The infection spreads rapidly to involve the overlying soft tissue, petrous temporal bone, skull base and neck spaces resulting in various complications like skull base osteomyelitis, multiple cranial nerve palsies (especially facial), subdural
empyema and cerebral abscess. CT is the investigation of choice and is useful in defining the anatomical extent of disease and also skull base involvement [6], [7].

4. Invasive Fungal Sinusitis

Invasive fungal sinusitis is found only in immunocompromised individuals, with uncontrolled diabetes mellitus being the most common cause. Inhaled fungal organisms are deposited in nasal passageways and paranasal sinuses and fulminant progression occurs over days to months, where the fungi invade mucosa, blood vessels and bony walls of paranasal sinuses. If treatment is delayed, there can be angio-invasion and hematogenous dissemination with resulting high mortality. CT demonstrates minimal circumferential mucosal thickening to complete opacification of paranasal sinuses, with variable T1 and T2 WI signal intensity on MR depending on protein concentration. There can be bony destruction without bony expansion with complications like orbital cellulitis (Figure 4), meningitis, cerebritis, fungal granulomas, cavernous sinus involvement (Figure 5) and maxillo-facial soft tissue swelling. Sometimes paranasal sinus walls may remain intact with fungal dissemination along perivascular channels of penetrating blood vessels with resulting complications [8,9].

5. Urinary tract infections: (Figure 6,7)

Urinary tract is the most common site of infection in diabetic patients and is 4 to 5 time more common in diabetics as compared to non-diabetics. Hyperglycemia, ketoacidosis and neuropathic dysfunction predispose diabetics to repeated urinary tract infection. The most common manifestation is asymptomatic bacteriuria, however if this not treated adequately can lead to symptomatic urinary infection like pyelonephritis, pyonephrosis and cystitis. Ultrasound can detect pyelonephritis only in 25% cases, however it is useful to evaluate hydronephrosis, renal calculi and to detect renal and perirenal abscesses. CT is the imaging modality of choice to evaluate renal infections. It shows bulky kidney with perinephric fat stranding, lesser enhancement as compared to normal kidney and striated nephrogram on delayed imaging. Complicated pyelonephritis can lead to renal and peri-renal abscess formation [10].

6. Emphysematous pyelonephritis: (Figure 8)

Emphysematous pyelonephritis is caused due to necrotizing infection of renal parenchyma by gas forming gram negative bacteria like E.coli, Kleibsella , Proteus mirabilus. 90 % of patients are uncontrolled diabetics, mainly females. USG can show hyperechoic dirty gas shadow with reverberation artifacts within the renal parenchyma and perinephric space; however it can be easily confused with small renal calculi. CT is imaging modality of choice to demonstrate air foci.
Depending on severity and clinical outcome it is classified in to two different types [10]. In type I, there is extensive renal parenchymal destruction with either streaky or mottled foci of air collection however the fluid collection in the perirenal space is characteristically absent. In type II, air foci are seen in the renal parenchyma or collecting system with fluid collection in perirenal space. The mortality rates in type I is 69% and in type II is 18% [11].

7. Adhesive capsulitis: (Figure 9)

Adhesive capsulitis is also called as frozen shoulder as there is temporary restricted movement at joint due to synovial inflammation and capsular thickening. It is mainly seen in females in the age group of 40-60 years with a higher prevalence in diabetics, most commonly affecting the shoulder joint and rarely the ankle joint. It can be primary (idiopathic) or secondary to trauma. It has three stages freezing, frozen and thawing each lasting for period of about 9-12 month.

MRI is the imaging modality of choice to demonstrate rotator cuff interval and inferior axillary pouch (inferior glenohumeral ligament) which are the main structures to be involved [12]. Thickening of inferior glenohumeral ligament (>4mm) can be seen in T1 or T2 weighted oblique coronal images. These oblique coronal images also effectively demonstrate thickening of superior glenohumeral and coracohumeral ligament covering rotator cuff interval which are also involved.

8. Diabetic foot: The diseases related to diabetic foot are osteomyelitis, acute and chronic Charcot osteoarthritis and Charcot disease with superadded osteomyelitis [13].

a) Osteomyelitis: It's a bone marrow disease involving pressure points of foot(calcaneum, metatarasal head and interphalangeal joints). Subcutaneous edema with subcutaneous ulcer and sinus tract extending in the medullary cavity is classical of osteomyelitis in diabetic foot.

b)Charcot osteoarthritis: Active Charcot osteoarthritis is disease of articular joint involving the mid foot with bone marrow edema in subarticular region and little subcutaneous edema. In Chronic Charcot stage due to joint deformity, subluxation and dislocation of the metatarsals there is loss of medial foot arch resulting in flat foot or rocker-bottom type of deformity. This deformity makes the cuboid bone as a weight-bearing structure. As the cuboid becomes the weight bearing bone, the overlying skin become vulnerable to ulceration and infection hence osteomyelitis superadded over chronic Charcot involves the cuboid bone (Figure 10).
Fig. 1: Hyperglycemia-induced hemichorea hemiballismus syndrome (HIHH): A 40 year old diabetic female with unilateral choreoathetoid movements. Plain CT (1a) show hyperdense left caudate nucleus and left putamen (arrowheads), which appeared hyperintense on T1w images(1b).

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Fig. 2: Non-Ketotic Hyperglycemic hyperosmolar syndrome (HHS) : 45 year female, a known case of DM since 10 years, presented with altered sensorium and very high blood glucose (700mg/dl). MRI T2W (2a) and FLAIR(2b) axial image revealed hypointensity (arrow head) in the left parietal sub-cortical white matter.

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Fig. 3: Malignant otitis externa : 70 year old diabetic female presented with severe headache since the last 3 months. Enhancing abnormal soft tissue (white arrowhead) is seen right external canal, middle ear cavity extending in overlying soft tissue, with erosion of bony external auditory canal (black arrowhead) and styloid process (white arrow).
**Fig. 4:** Fungal Sinusitis complication - Orbital Cellulitis: 55 year diabetic male presented with diplopia. Post-contrast axial CT revealed bilateral ethmoidal sinusitis with extension into the medial extra-conal compartment (arrow head) (4a) of the left orbit through the eroded left lamina papyracea (arrow head) (4b).

**Fig. 5:** Fungal Sinusitis Complication- Cavernous Sinus Thrombosis: Poorly controlled diabetic patient with headache and diplopia. CT revealed hyperdense opacification of sphenoid sinus (white arrow head) with erosion of the right lateral wall of sphenoid sinus (black arrow head) and extending into right cavernous sinus which shows filling defect (arrow) on post contrast study.
**Fig. 6:** Pyelonephritis with renal Abscesses: 58 year old diabetic female presented with high grade fever with chills and pain in right lumbar region. Contrast enhanced CT revealed bulky right kidney with poor cortico-medullary differentiation (white arrow), moderate hydronephrosis (black arrow head)(6a). Multiple tiny hypo-enhancing foci were noted in right kidney s/o renal abscesses(white arrow head)(6b).

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**Fig. 7:** Renal Abscesses extending in peri-renal space: 42 year old diabetic male presented with high grade fever with chills. Contrast enhanced CT revealed heterogeneously enhancing lesion(arrow head) in the posterior part of left renal cortex which was seen extending into perirenal space.

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Fig. 8: Emphysematous pyelonephritis: 68 year old diabetic female patient presented with severe pain in left hypochondrium and high fever. CT Tomogram revealed reniform shaped radiolucencies in the left renal fossa (arrow head) (7a). Axial sections of plain CT revealed bulky left kidney, with destruction of almost its entire parenchyma which is replaced by air (arrow head) (7b).

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Fig. 9: Adhesive capsulitis: 58 year old diabetic presented with restricted painful movements of the right shoulder. MRI T2 (9a) oblique coronal showed thickening of IGHL (arrowhead) with abnormal hyperintense signal on STIR(9b).

Fig. 10: 48 year old diabetic patient on insulin, with non-healing ulcer since 1 year presented with erythematous swollen foot. MRI PDFS revealed loss of longitudinal foot arch with deformed, dislocated tarso-metatarsal (TM) joint with destruction of cuboid and base of 4th metatarsal, associated with abnormal peri-articular soft tissue (black arrow) which shows air foci within (white star). Bone narrow edema (black star) is noted in metatarsal, cuboid and calcaneum. An ulcer (white arrowhead) is seen in the dorsal aspect of foot overlying the TM joint. Abnormal soft tissue collection (black arrowhead) is also noted in the sub-cutaneous region anterior to lower tibia.
Conclusion

Knowledge of the common and pathognomonic CT & MRI findings in diabetics and their differential diagnosis is essential for a radiologist. On a few occasions, we have prompted the referring clinician to look for diabetes in view of the radiological findings favouring diabetes. Hence, greater awareness of the different pathologies in diabetics and their radiological findings would lead to improved diagnosis and better management.
References


