ORBITAL Ultrasonography a diagnosis tool in early cellulitis

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***Abstract*: The term cellulitis in general parlance refers to non-suppurative invasive infection (most commonly bacterial) of subcutaneous tissue. Spreading infection, poor localization in addition to cardinal signs of inflammation are the hallmark of cellulitis. Cellulitis can be complicated by spread of infection to the underlying deeper structures with progressive tissue destruction & ulceration with release of bacterial toxins. (1)**

Orbital cellulitis is an infection of the fat and ocular muscles of the orbit posterior to the orbital septum. It is classically distinguished clinically from pre-septal cellulitis by the presence of pain with eye movement and proptosis on physical examination (1, 2). What makes cellulitis in the preseptal, orbital & retro-orbital soft tissue regions different from generalized cellulitis are the transitional anatomical differences from preseptal (Eyelid skin) to adnexal/orbital to intracranial structures and the presence of well recognized anatomical/surgical sub-compartments. Preseptal cellulitis follows pattern similarities to generalized cellulitis characterized by eyelid edema, eyelid erythema, local rise of temperature and tenderness. Unlike pre-septal cellulitis, orbital cellulitis is considered a medical emergency. If left untreated, it can lead to permanent vision loss, brain abscesses, meningitis, and cavernous sinus thrombosis (3). Though the diagnosis of orbital cellulitis can be made clinically, imaging modalities such as computed tomography (CT) and Orbital Ultrasonography are commonly used to confirm the diagnosis. (4)

The present study was designed to provide sequential imaging to visualize the disease progression.

***Keywords*: Orbital Ultrasound, Orbital Cellulitis, Facial Cellulitis, Preseptal Cellulitis**

I. INTRODUCTION

There are various forms of diseases that involve the orbit and therefore the discussion of those disorders are often organized in line with the etiology (e.g., infection, inflammation, neoplasm) or by anatomic location.

Findings on examination that warrant imaging studies include pain on eye movement, afferent pupillary defect, limited extraocular motions, resistance on retropulsion, and arterialization of conjunctival blood vessels. Image findings in pre-septal cellulitis include the following:

- Swelling of the eyelid and adjacent pre-septal soft tissues
- Obliteration of the fat planes or details of the pre-septal soft tissues
- Absence of orbital inflammation

A CT scan can delineate the extent of orbital involvement. The modified Chandler staging system (5) describes the spectrum of orbital cellulitis as follows (in the order of severity /progression)

- Stage I – Pre-septal cellulitis
- Stage II - Inflammatory orbital edema
- Stage III - Subperiosteal abscess
- Stage IV- Orbital abscess
- Stage V - Cavernous Sinus Thrombosis

The above-mentioned stage 5 can be further complicated by Subdural Empyema

As the cellulitis spreads with involvement of deeper orbital structures, there is proptosis, conjunctival chemosis, limitation of ocular motility, drop in visual acuity, with progressive optical nerve dysfunction, reduced corneal & periocular sensation. Chandler's classification describes staging of orbital cellulitis and guides the management of orbital cellulitis till date.

Lacrimal gland pyoadenitis/pyomyositis of the extraocular muscles are also pyogenic complications of orbital cellulitis and relatively rarer clinical presentations (not included in Chandler's classification) The other interesting fact to consider that probably contrasts generalized and orbital cellulitis are the systemic complications secondary to hematogenous spread, occurrence of systemic inflammatory response syndrome seen commonly in generalized cellulitis while intracranial complications due to local contiguous spread rather than hematogenous spread is the pattern seen repeatedly in the orbital region. The possible reason to consider here are the uniqueness of vascular supply in the orbital region. The eyelids are supplied by the external carotid system with good collateral circulation while the orbital and adnexal tissues are supplied by the internal carotid system characterized by specific end organ vessel branches. This probably reduces the chances of direct systemic spread from the orbital region and at the same time increases the risk of intracranial complications if managed inadequately.

A CT scan of the orbit is not necessary for all cases of pre-septal cellulitis. For older patients who clearly have limited infection, conservative management is appropriate. When it is unclear whether deeper orbital structures are involved (e.g.,

limited ocular motility), a CT scan or an orbital ultrasound is indicated. Consider imaging in all children with an advanced presentation or if a foreign body is suspected. (5)

Ultrasonography provides extra structural details on clinical diagnostic appurtenant testing which enhances the clinician's ability to understand anatomical structures and comanage complicated pathology. (6-9) A review of the current literature shows few examples in which ultrasonography was used to visualize or confirm the findings of orbital cellulitis (10–15).

II. DISCUSSION

Pathological processes inside the orbits are a heterogeneous cluster of diseases of varied etiologies, clinical entities and pathological models. Because of poor access to the orbits during a clinical examination, imaging plays a vital role in both identification and treatment monitoring in patients with an orbital pathology.(13)It is indicated, for instance, in orbital cellulitis , exophthalmos, globe mobility disorders, globe displacement, lacrimal gland swelling, endocrine orbitopathy, suspicion of muscle inflammation or scleritis, orbital injury, optic disc oedema, choroidal folds, abrupt refractive changes (hyperopia, astigmatism), episcleral vein dilation, and globe or orbital pain of unclear etiology.(16)

Inflammatory diseases of the orbits could also be infectious or noninfectious. Of the infectious, Orbital cellulitis is the commonest and usually arises as a complication of acute sinusitis. However an orbital cellulitis has been observed post Craniofacial Trauma with contaminated facial wounds, retained Intra orbital Organic foreign body, Inadequately treated Eyelid infections or Inadequately treated acute on chronic dacryocystitis with underlying nasolacrimal duct obstruction.

Of the noninfectious, inflammatory conditions, thyroid orbitopathy is the commonest and leads to enlargement of the extraocular muscles and proliferation of the orbital fat. Idiopathic orbital inflammatory syndrome is another reason for inflammation within the orbit, which can mimic thyroid orbitopathy or perhaps tumor, but generally presents with pain. (17-18)

Standard ultrasound images are typically obtained in an antero-posterior direction either during a cross, axial or longitudinal plane, or during a plane slightly oblique to one of these planes. Some ocular pathologies could be viewed from a mediolateral orientation or oblique orientation, and these views might not be adequately achieved using standard two-dimensional ultrasound. (19)

Ultrasonography contains a wide selection of clinical indications. For instance, when examining a patient with ocular discomfort or pain, clinicians will use ultrasound to ensure a diagnosis of inflammation, orbital myositis, or dacryoadenitis. Imaging is often used to identify retrobulbar tissue, as well as the extraocular muscles, in patients with symptoms and suspected soft tissue enlargement secondary to Graves' disease.

Time gain compensation (TGC) is a setting applied in diagnostic ultrasound imaging to account for tissue attenuation. By increasing the received signal intensity with depth, the artifacts in the uniformity of a B-mode image intensity are reduced. The purpose of TGC is to normalize the signal amplitude with time, compensating for depth.

The application of color-coded Doppler ultrasonography is especially important in the assessment of the vasculature of retrobulbar tumorous lesions and in the differential diagnosis of intraocular tumors. (20)

The goal of 3D imaging is to reconstruct the orbit into a three-dimensional image using multiple two-dimensional B-scans. While it is difficult to understand what every image represents when piecing the two-dimensional B-scan pictures to reconstruct the eye and orbit in 3 dimensions, there are several approaches and individual methods to the examination, the secret to which is to make sure there is an organized, repeatable approach to evaluating the complete orbit and globe. (Figure 1) (21-23)

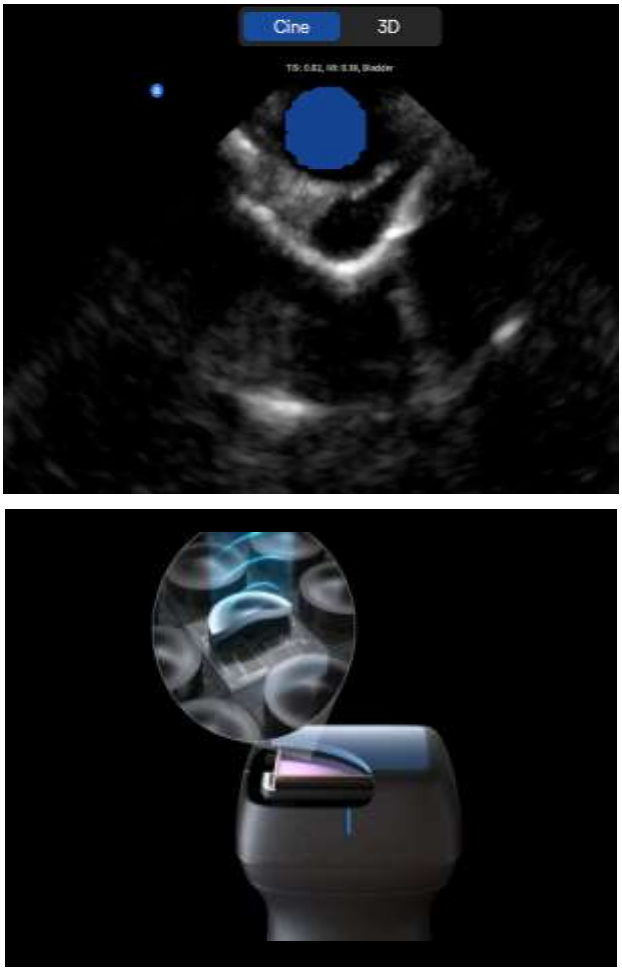
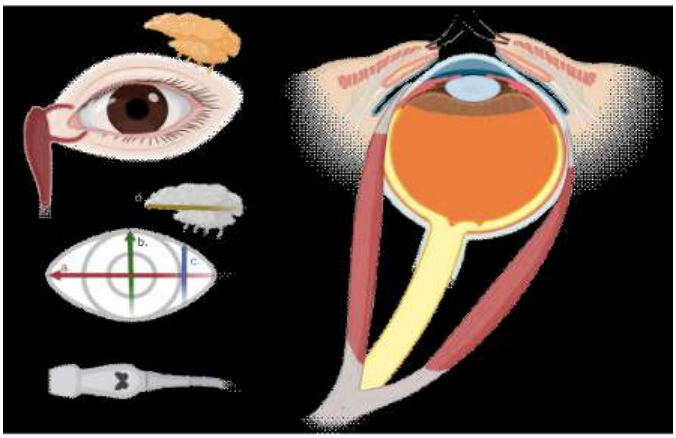


Figure 1: Large Intra-Orbital Abscess with delineation and 3D configuration extended to extraconal space using Butterfly IQ+ Handheld Ultrasound.

Orbital ultrasonography instructional diagram (Created with BioRender.com)



Standard operating procedure for Facial ultrasonography (22): (Figure 2)

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III. LIMITATIONS

Orbital ultrasonography has some limitations. It is an operator-dependent diagnostic method with equivocal results in differencing the exact penetration of inflammation and exudates in preseptal and post septal cases. It also lacks appropriate accuracy in defining the paranasal sinus pathology, bony involvement and calcifications. It needs close contact of the probe to the surrounding soft tissues which could cause pain and discomfort for the patient. Its image resolution is also limited compared to other visualization modalities. However, ultrasound is an immediately available and rapidly performed diagnostic tool without the risk of ionizing radiation. This cost-effective tool gives the freedom of reassessment during the follow-up visits.

Possible limitations when one uses an ultrasound in these clinical scenarios is to:

1) Avoid placing the probe over discharging open wounds
2) Difficulty in assessing the superior Subperiosteal space compared to the other spaces of the orbit since the probe placement becomes difficult inferiorly especially in those with prominent maxillae.

IV. CONCLUSION

In a time of profound technological advancement in ocular imaging, orbital ultrasonography has often been relegated to a niche/ancillary test. With affordability of available ultrasonography systems, now is the time to take advantage of the many applications of ultrasonography to best serve your patients.

Challenges to using imaging are generally associated with the clinician's familiarity with the technique and competence level with image interpretation. Whereas highly-trained, highly-skilled echographers are true specialists with the art of acquiring and decoding pictures, an understanding of the fundamental technique of performing the scan and deciphering its results are still quite helpful in clinical practice.

Declaration of Helsinki:

This review is adhered to the ethical principles outlined in the Declaration of Helsinki as amended in 2013. (https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/).

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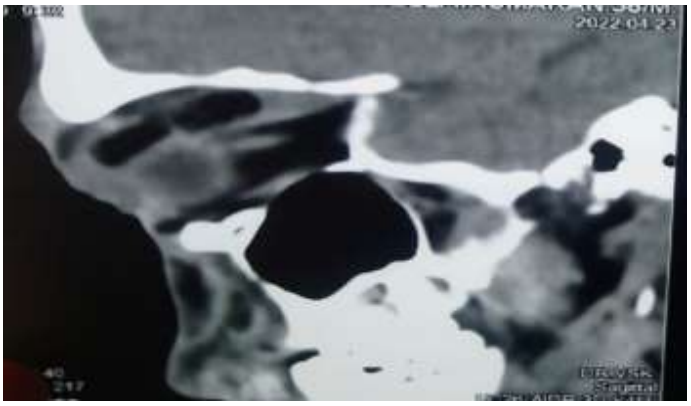
*Supplement***:**

Clinical presentation - stage 4 orbital cellulitis with deep Intra-Orbital abscess.

CT scans Axial and sagittal views to know the extent of the foreign body and surrounding air-fluid levels suggesting an abscess.

The following clinical pictures from a case scenario, A superomedial sub periosteal space wooden foreign body relatively more comfortable to assess by USG.



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