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"Advance Use of Ultrasonography (USG) In Oral Maxillofacial Surgery and Oral Medicine"

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ABSTRACT-Ultrasonography is a noninvasive and less expensive diagnosticmethod. Non-utilization of x-rays adds to its advantage and it is also easily available. It is capable of showing fine structures with considerable detail. Hence with the development of more advanced techniques, new applications of its use as an adjunct to clinical practice continues.

KEYWORDS- Ultrasonography, hypoechoic, hyperechoic, anechoic.

INTRODUCTION-

Ultrasonography(USG) was clinically introduced by Dussik in 1942. Since then, the application of Ultrasonography has been extended to various fields of clinical practice as an imaging method.[1]

Ultrasonography is a study of internal organs or blood vessel using high frequency sound waves, the actual test called ultrasound scan or sonogram. Ultrasound is a sound waves of frequencies greater than audible to human ear i.e. greater than 20,000Hz. Frequencies between 1 to 10 MHz are mainly used for the purpose of diagnostic ultrasound.

Ultrasonic vibrations travel in the form of a wave, similar to the way light travels. However, unlike light waves, which can travel in a vacuum (empty space), ultrasound requires an elastic medium such as a liquid or a solid. Ultrasonography uses a probe containing multiple acoustic transducers to send pulses of sound into a material. A transducer is any device that converts one form of energy to another. An ultrasonic transducer converts electrical energy to mechanical energy, in the form of sound, and vice versa.[2]

MECHANISM -

As sound energy passes from a tissue of one acoustic impedance to another, some is reflected, some continues to penetrate, and some is transferred to particles within the medium in the form of vibration energy. The echoes reflected to the transducers are reconverted into electrical energy, after which they are amplified and processed and finally displayed on a screen.

The sonographic images are identified in terms of echoes as hypoechoic, hyperechoic and anechoic images. A mass is hypoechoic if it has a intensity lower than that of the adjacent tissue. Hyperechoic is used for masses of higher intensity and isoechoic is used for masses with intensity similar to the adjacent tissue. The appearance of hypoechoic masses is darker whereas the hyperechoic masses appear rather bright, and the isoechoic ones have a similar appearance. A calcified mass appears hyperechoic and a clear fluid or blood appears anechoic.(FIG.01 A, B, C, D)

The capacity of Ultrasound to depict normal structure and to identify tissue pathosis is a result of "visual" tissue characterization. Tissues absorb, reflect, and scatter the sonic waves in a variety of ways. Some, such as the diaphragm,

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are strong reflectors, which behave as mirrors ("specular reflectors"). Sound from specular reflectors returns to the transducer only when the transducer is perpendicular to the reflector.

Most tissues, however, scatter the sound in all directions, and their image may therefore be perceived by the transducer, regardless of its orientation. The visual pattern of relative echo amplitudes returning from scattering-type tissues makes possible the differentiation of normal pathologic conditions.

Another major component of the sonographic appearance of tissues is the phenomenon of acoustic shadowing. Acoustic shadowing is produced by the reflection or refraction of the sound beam. An example is calcium, which produces strong reflected echoes and at the same time, markedly attenuates the sound beam. The tissues immediately distal to calcified structures are thus obscured by acoustic shadowing.

On the other hand acoustic enhancement occurs distal to fluid filled structures, fluid causing little attenuation of the beam. This feature is a major diagnostic characteristic, making possible the differentiation between solid and fluid sonolucencies.

The degree to which these effects occur depends upon the relative density of the fluid or calcified structure.[3, 4]

MODES OF ULTRASOUND-

Several modes of ultrasound are used in medical imaging. These are:

1. A-mode: A-mode (A-scan, amplitude modulation) is a one-dimensional examination technique in which a transducer with a single crystal is used. The echoes are displayed on the screen along a time (distance) axis as peaks proportional to the intensity (amplitude) of each signal. The method is rarely used today, as it conveys limited information, e.g. measurement of distances.
2. B-mode: B-mode (brightness modulation) is a similar technique, but the echoes are displayed as points of different grey-scale brightness corresponding to the intensity (amplitude) of each signal.
3. M-mode or TM mode: M-mode or TM-mode (time motion) is used to analyse moving structures, such as heart valves. The echoes generated by a stationary transducer (one-dimensional B-mode) are recorded continuously over time.
4. B-scan, two-dimensional: The arrangement of many one-dimensional lines in one plane makes itpossible to build up a two-dimensional (2D) ultrasound image (2D B-scan). The singlelines are generated one after the other by moving (rotating or swinging) transducersor by electronic multielement transducers.
5. Three- and four-dimensional techniques: The main prerequisite for construction of three-dimensional (3D) ultrasoundimages is very fast data acquisition. The transducer is moved by hand or mechanicallyperpendicular to the scanning plane over the region of interest.The collected data are processed at high speed, so that real-time presentation onthe screen is possible. This is called the four-dimensional (4D) technique (4D = 3D + real time). The 3D image can be displayed in various ways, such as transparent views of the entire volume of interest or images of surfaces, as used in obstetrics and not only for medical purposes. It is also possible to select two-dimensional images in any plane, especially those that cannot be obtained by a 2D B-scan.

6. B-flow: B-flow is a special B-scan technique that can be used to show movement without relyingupon the Doppler Effect. The echoes from moving scatterers (particularly blood cellsin blood vessels) are separated from stationary scatterers by electronic comparison of echoes from successive pulses (autocorrelation). These very weak echoes are amplifiedand depicted as moving dots on the screen. This technique is effective in showing the inner surface of blood vessels, but, unlike doppler methods it provides no information about flow velocity.
7. Doppler techniques: Christian Doppler (1803-1853), an Austrian mathematician known for the principle he first proposed in concerning the coloured light of double stars in 1842 known as Doppler effect. He hypothesized that "the pitch of a sound would change if the source of the sound was moving."In these techniques, the Doppler Effect is used to provide further information invarious ways, as discussed below. They are especially important for examining blood flow.
   i. Continuous wave Doppler: The transducer consists of two crystals, one permanently emitting ultrasound and the other receiving all the echoes. No information is provided about the distance of the reflector(s), but high flow velocities can be measured.

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ii. Pulsed wave Doppler: In this technique, ultrasound is emitted in very short pulses. All echoes arriving at the transducer between the pulses in a certain time interval (termed the gate) are registered and analyzed.
iii. Spectral Doppler: The flow of blood cells in vessels is uneven, being faster in the centre. Doppler analysis, therefore, shows a spectrum of different velocities towards or away from the transducer, observed as a range of frequencies. All this information can be displayed together on the screen.

The spectral Doppler approach combined with the B-scan technique is called the duplex technique. The combination of B-scan with colour Doppler and spectral Doppler is called the triplex technique.[5]

INDICATIONS OF ULTRASONOGRAPHY-

1. Soft Tissue Lesions-

Ultrasound imaging is used-

i. to visualize foreign bodies in soft tissues,
ii. guided fine needle aspiration,
iii. measurement of tongue cancer thickness, and
iv. Diagnosis of metastasis to cervical lymph nodes.

The Doppler mode in ultrasound is useful in the differential diagnosis between normal and metastatic lymph nodes in patients with oral squamous cell carcinoma; and also to differentiate between benign and metastatic lymph nodes. It is mandatory to estimate the depth of invasion in order to predict the subsequent cervical lymph node metastases in patients with tongue carcinoma. The sonographic feature of the three-layer structure of tongue mucosa demonstrated on intraoral USG is useful to estimate the depth of tumor invasion of superficial carcinoma of the tongue because the increasing depth of tumor invasion and the microvascular proliferation caused by neoplastic growth might determine proximity to blood vessels and lymphatics, thus facilitating the tumor's ability to metastasize.

2. Diagnosis of Fascial Space Infections-

It demonstrates the stages of infections and hence aids the surgeons towards a successful management.

3. Major Salivary Gland or Duct Stone and Salivary Gland Lesion Detection-

USG can be used to detect parotid lesions, where solid and cystic lesions are reliably differentiated and diffuse enlargement of the parotid gland or focal disease is readily shown.

Sonographically, benign lesions usually look well defined, homogeneous and hypoechoic; while malignant lesions tend to be ill defined and hypoechoic with heterogeneous internal architecture. Enlarged cervical lymph node may be visible and reactive intra parotid lymph nodes may also be readily assessed.

USG can also be used for detecting Sialoliths in Parotid, submandibular and sublingual salivary glands, which appear as echo-dense spots with a characteristic acoustic shadow.

4. Periapical Lesions-

The use of USG in the differential diagnosis of periapical lesions was introduced by Cotti et al. in 2002 and 2003. They defined cystic lesion as a hypoechoic well-contoured cavity filled with fluids with no evidence of internal vascularity on power Doppler imaging; and granuloma as a hyperechoic or mixed hyper- and hypoechoic areas with a rich vascular supply on power Doppler imaging.

The USG with Doppler imaging also found effective in monitoring the healing of periapical lesions after surgery and for differentiation between vital and root filled teeth.

5. TMJ Imaging, Detection of Fracture and Vascular Lesions-

USG is found useful in providing the information of disk position, joint effusion and bone abnormalities for the evaluation of temporomandibular joint disorders (TMD). USG had been widely used to detect effusion in many musculoskeletal areas by depicting the presence of intraarticular fluids in larger joints.

USG in dentistry is used for detection of fractures of the Maxillo facial region i.e Nasal bone fractures, Orbital rim fractures, Maxillary fractures, Mandibular fractures, Zygomatic arch fractures and for locating the position of Mandibular condyles. Post operative view can also be done instantly to view the reduction & healing of fractures.

In Ultrasound, color Doppler sonography has been developed to identify vasculatures and to enable evaluation of the blood flow, velocity and vessel resistance together with surrounding morphology. Hence, it can be used for detecting the course of the facial artery and for detecting hemangioma. It also helps in visualization of vessels of the neck including the carotid for atherosclerotic plaques.

6. Muscle Thickness-

USG is capable of providing uncomplicated and reproducible access to the parameters of jaw muscle function and interaction within the cranio-mandibular system. Hence this method represents a significant improvement over conventional methods to evaluate masseter thickness, especially in terms of clinical availability and cost.

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The role of USG in measuring the muscle thickness may provide useful information in diagnosis and treatment especially during follow up examination.

7. Dental Scanning-

Considering the importance of detecting caries lesions at an early stage and correctly quantify the degree of mineral loss to ensure that the correct intervention is implemented, a range of new detection systems have been developed, and among them one is US imaging technology.

Most solids, including enamel and dentin can be penetrated by USG, and hence it is helpful to detect dental caries, dental cracks and fractures present at the dentinoenamel junction (DEJ).

8. Dental Implants-

Determination of gingival thickness over implants is crucial for the selection of appropriate abutments, restorative components, and treatment planning. Moreover, implant location after healing is difficult, especially when implants are deeply submerged after thick connective tissue grafts. Radiographic assessment of healed implants only provides 2-D information, which may be difficult to accurately relate it to the 3-D surgical site.

Thus USG plays an important role in determination of the gingival thickness and also locating the submerged implants.

Some of the most common medical problems that warrant the use of ultrasound therapy are-

1. Adhesive capsulitis (“frozen shoulder”, or pain and stiffness in the shoulder caused by inflammation),
2. Calcify bursitis (the calcification of bursa sacs due to prolonged inflammation, usually in the shoulder),
3. Inflammation of the skeletal muscles (myositis), and soft tissue injuries from sports or other causes.
4. Ultrasound therapy is also used to treat tendons that have been shortened from untreated scar tissue or past injuries.
5. Ultrasound can be used to overcome capsular tightness or scarring, which often results from surgeries such as breast augmentation.
6. The spatial selectivity of the pulse-Doppler is valuable when investigating movement in and around the heart. Murmurs have been localized using Doppler by detecting blood turbulence within the heart and great vessels.
7. Obstetrical sonography is commonly used during pregnancy to check on the development of the fetus.[6, 7, 8, 9]

CONTRAINDICATIONS OF ULTRASONOGRAPHY-

1. Eyes-

Ultrasound therapy is contraindicated over the eyes. In the book "Thermal Agents in Rehabilitation," author Susan L. Michlovitz explains that due to the poor blood supply to the eye, the heat from the ultrasound can build up. This might lead to retinal damage and increased risk for cataracts.

2. Pregnant Women-

Therapeutic ultrasound should not be applied to the abdomen of pregnant women. Unlike diagnostic ultrasound, in which harmless sound waves are used to provide an image of the developing fetus, ultrasound therapy often involves deep penetrating heat and vibration. Health Canada's Guidelines for the Safe Use of Ultrasound suggests that ultrasound therapy could overheat the fetus which can possibly lead to a birth defect, especially if administered during the first trimester.

3. Testicles-

Ultrasound therapy applied over the testicles is contraindicated, due to the potential for producing short-term heat-related sterility.

4. Cancer-

Application of ultrasound therapy to cancerous tissue should be avoided. According to Thermal Agents in Rehabilitation, research suggests this could promote metastasis, or spreading of the cancer cells to other parts of the body.

5. Infection-

Localized tissue or bone infections are contraindicated for treatment with therapeutic ultrasound, explains Health Canada. The heat from the ultrasound therapy increases the likelihood of spreading the infection.

6. Pacemakers-

Health Canada discourages the use of ultrasound over the chest of patients with cardiac pacemakers. The sound waves could interfere with the performance of the pacemaker.

7. Thromboembolic Disease-

Patients with thromboembolic disease, or blood clots, should avoid ultrasound therapy, explains Health Canada, since the heat might increase the risk of a clot dislodging.

8. Laminectomy-

Therapeutic ultrasound should not be performed over the spine after a laminectomy, suggests the Family Physiotherapy Centre of London. Doing so carries risks of injury to the spinal cord.

9. Metal Implants-

Due to the tendency of metal to have higher heat conductivity than tissue, ultrasound therapy should never be used directly over metal implants because of the risk for burns.[10, 11, 12]

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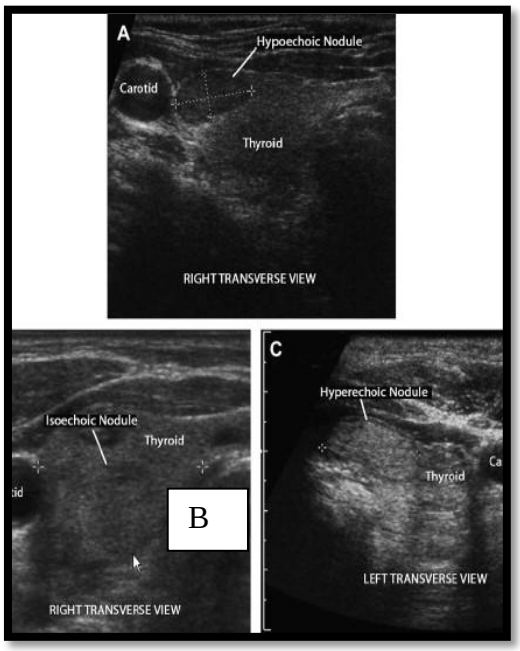
ADVANTAGES OF ULTRASONOGRAPHY-

1. It is a dynamic and readily available technique.
2. It is particularly useful in the examination of superficial structures.
3. It is widely available and relatively inexpensive.
4. It is a non-invasive technique.
5. It is well tolerated by the patient.
6. It does not interfere with normal function.
7. Artifacts are few.
8. The technique is highly acceptable to most patients.
9. Images are rapidly acquired.
10. Images are simple to store and retrieve.
11. Images obtained are easy to read once the observer is trained.
12. It can be performed without heavy sedation.
13. It has no known cumulative biological effects.
14. It is proven to be reproducible and simple.
15. Equipments are portable.
16. It is easily accessible and painless.
17. It is a less discomfort, relatively rapid and examination can be performed even at the patient's bedside.
18. Its absolute non ionizing nature.
19. Equipments are relatively cheap.
20. It is convenient to use.
21. Its possibility of real time imaging.
22. It helps to distinguish between solid and cystic lesions.
23. Its ability to detect non calcified pathological entities such as sialoliliths.

DISADVANTAGES-

1. The technique is very operator- and equipment dependent.
2. Clinically only the bone surfaces and not the whole cortex or spongiosa can be visualized in intact done due to ultrasound frequencies.
3. It has to be performed by experienced investigators.
4. Images when archived they may be difficult to orientate and to interpret unlike CT and MR scans, which have acquired in standard reproducible scans.
5. The difficulty of picturing the TMJ using ultrasounds depends on the limited accessibility of the deep structures, especially the disc, due to absorption of the sound waves by the lateral portion of the head of the condyle and the zygomatic process of the temporal bone.
6. Ultrasound images are affected by inherent noise accompanying the signal returned to the transducer which makes interperatation of the static images, and sometimes the dynamic ones as well and a nonmoving object will vary in appearance because of this noise.
7. Ultrasonography waves do not visualize bone or pass through air, which acts as an absolute barrier during both emission and reflection.[13]

Fig No : 1



DIFFERENT USG APPEARANCES-

- **A. HYPOECHOIC IMAGE,**
- **B. ISOECHOIC IMAGE,**
- **C. HYPER ECHOIC IMAGE,**
- **D. ANECHOIC IMAGE**

CONCLUSION-

USG has several advantages over conventional radiography namely its noninvasive nature, non radiating, easy reproducibility, possibility of real time imaging and its ability to detect various pathological entities. It is also widely available, relatively rapid and an

inexpensive technique. In spite of this, it is not routinely being used as preliminary diagnostic modality. But it is a valuable tool and will showing promising results in the recent years.

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