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Review Article

Ultrasonography - Visualization by Waves

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Abstract

Ultrasonography is a simple, non-invasive, provides dynamic imaging which helps in diagnosis as well as therapeutic mode of action of the area of interest. Ultrasound device uses a transducer to convert electrical impulses to high-frequency ultrasound waves and the reflected sonic waves is recorded and used for diagnostic purposes. Ultrasonography has proven its worth over the time as the diagnostic modality in the field of medical imaging and is constantly being upgraded by 3D visualization and the use of contrast. However, it still lacks the power of being a primary standalone diagnostic tool. Further, its use as a therapeutic modality is being recognized and appreciated and is soon to become the preferred choice without any adjuncts for diagnostic or therapeutic purposes.

Keywords: Ultrasonography; Scan; Waves; Diagnostic; Therapeutic; Imaging

Introduction

Diagnosis requires clinical as well as imaging and laboratory procedures. The ability to diagnose the disease process by ultrasonography is an age old proven fact dating to as early as the late 1800s when Jacques and Pierre Curie found that high-frequency sound waves are produced when certain crystals were imperiled to an alternating current at their resonating frequency and later Paul Langevin in the year 1926 reported the biological effects of ultrasound after witnessing the intense, lethal and deadly reaction of fish to robust ultrasound arenas [1-5].

Ultrasonography provides dynamic imaging (also known as real-time imaging) with the live motional changes observed of the area of interest, which helps in diagnosis as well as therapeutic mode of action. Over the years, USG has advanced from two-dimensional form to three-dimensional imaging modality. Further, the addition of contrast medium to the imaging modality has improvised the visualization for the physicians [1-5].

Principles of ultrasound

Ultrasound device runs on the concept of conversion of electrical impulses to high-frequency ultrasound waves by a transducer.

The transducer is a device capable of converting one form of energy into another form of energy with the piezoelectric crystal (lead zirconate titanium acting as the primary component of the transducer [6]. On application of electrical impulse on the transducer leads to series of vibrations within the crystal producing sound waves which are transmitted to the body tissues within the area of interest. Later the reflected sonic waves are reflected and recorded which is further converted to electrical signals leading to amplification and later available for display on the monitor for visualization.

The range of frequency used in therapeutic ultrasound and diagnostic ultrasound is 0.7-3.0 MHz and 1-20 MHz respectively [7].

Mechanism of action of ultrasound [8]

Ultrasound has both

- Thermal
- Non-thermal properties

Thermal effects

Also known as Continuous wave exposure working at intensities of 1-1.5 watts/cm2 producing vibrations which in turn lead to heat production at the area of interest and increasing the blood flow (removes inflammatory mediators and restores the nutrients) [8,9].

Non-thermal effects

Also known as pulsed exposure, this can be used in 2 forms

- Acoustic streaming
- Cavitation

Acoustic streaming is the unidirectional movement of fluid along cell membranes caused by the ultrasound or mechanical pressure wave pushing fluid past these structures.

Cavitation is the mechanical pressure waves within the biological fluid by compression and consequent decompression of the microscopic gas bubbles [10].

Advantages of ultrasonography [1,11]

- It provides dynamic imaging
- Easily available
- Relatively inexpensive
- Non-invasive and requires no incision
- It is widely available and relatively inexpensive
- Well tolerated by the patient
- Equipment are portable
- Fewer Artifacts
- Sedation is unnecessary
- Provides instant images
- No intervention required
- No aftereffects
- Can be repeated multiple times
- Sometimes has therapeutic effect along with diagnostic capability

Disadvantages of ultrasonography [1,11]

- Requires a well-trained professional
- Only the surface can be assessed and not the complete internal structure
- Sometimes may not be the only imaging modality and can be used only as an adjunct
- No standardized method available
- Reproduction of the same images is difficult
- USG waves are incapable of passing through air
- Bone visualization is limited
- Needs trained professionals

Uses of ultrasound [1,11]

- Diagnosis of swellings in the orofacial region
- Diagnosis of Salivary gland disorders and management
- Diagnosis of Lymph nodes enlargement
- Bony intraosseous lesions
- Temporomandibular disorders and management
- Assessment of masticatory muscles in temporomandibular dysfunction
- Vascular lesions of the orofacial region
- Primary lesions of the tongue
- Fractures of mid-facial and lower-facial fracture
- Detection of foreign bodies
- Osseo-integration

Inflammatory swellings [1]

- Ultrasonography may show variable results varying from hypoechoic-isoechoic-hyperechoic-anechoic. It appears as bright, equal or isometric, dark and without any changes in hyperechoic, isoechoic, hypoechoic and anechoic.

- Both cyst as well as benign neoplasms are hypoechoic with clear borders and rarely irregular in shape.

Cyst [12]	USG appearance
Radicular cyst	Hypoechoic to totally anechoic lesions
Odontogenic keratocyst	Hypoechoic lesions
Dentigerous cyst	Anechoic to focal hyper echogenicity

Table a

Further, use of USG as a dynamic imaging modality during the exploratory process with a safe passage while preserving vital structures and drainage of the abscess is being advocated. The main advantages being preservation of vital structures and minimal damage with minimal/no scar formation [13].

Neck and cervical lymph nodes

Ultrasonography shows hypo echogenicity in the normal lymph nodes and can differentiate benign as well as malignant lymph nodes. The sensitivity of ultrasonography for in assessment of cervical lymphadenopathy is 96.8% and Specificity of USG is 93% when combined with fine-needle aspiration cytology [14].

Malignant lymph nodes may appear malignancy, irregular margins or blurred margins because of their invasive nature [15].

Recurrent aphthous stomatitis

Recurrent aphthous stomatitis (RAS) appear as multiple recurrent small, round, or ovoid ulcers with circumscribed margins manifesting as minor, major, or herpetiform type. It has been reported that low-intensity ultrasound is useful to treat canker sores by increasing angiogenesis and/or by inducing granulation tissue formation and/or altering oral microflora [16].

Salivary gland diseases

Major salivary glands may appear as bright to somewhat hyperechoic against the hyperechoic muscle band adjacent to it. It can also differentiate between solid and cystic masses as well as in diagnosis of acute/chronic inflammation, sialolithiasis, sialosis as well as Sjogren syndrome [17,18] Tumors like pleomorphic adenoma and warthin's tumor are hypoechoic, well-defined and ovoid in appearance [19,20].

Salivary stones can be managed by extracorporeal shock wave lithotripsy by using high energy shock waves to break down the salivary stones, especially in the parotid and submandibular glands when the salivary gland stone is less than 7 mm [11].

Temporomandibular joint disorder

American Academy of Craniomandibular Disorders in conglomeration with Minnesota Dental Association has proposed physical therapy for the management of the disease process which can be accomplished by ultrasonography by motion and thermal effects which may reduce the inflammation and the musculoskeletal pain, which in turn helps in reestablishing the oral motor function [23].

USG appearance [21,22]	Area of interest
Hyperechoic	Margin of the bone Surface of the joint capsule Surface of the muscles
Hypoechoic	Articular eminence Mandibular condyle
Hyperechoic, Hypoechoic, or Isoechoic	Articular disc

Table b

In Ultrasound therapy, high-frequency sound waves are directed to the TMJ, to reduce inflammation which helps to increase circulation and eliminate the inflammatory mediators helping to reduce pain as well as swelling [13].

Oral submucous fibrosis

Oral submucous fibrosis (OSMF) shows increased hyperechoic areas due to fibrous bands/diffuse fibrosis with normal/decreased vascularity [1].

Ultrasonography is useful as a therapeutic modality by providing pain relief and increasing the stretch levels of the collagen fibers [24].

Hemangioma

USG shows a homogeneous, hyperechoic mass with well-defined margins as well as posterior acoustic enhancement [25].

Muscle

Ultrasound imaging helps in diagnosis of muscle inflammation/ hypertrophy with an exact outline of the muscle with known or unknown etiology [1].

Conclusion

Ultrasonography has proven its worth over the time as the diagnostic modality in the field of medical imaging and is constantly being upgraded by 3D visualization and the use of contrast. The simple, non-invasive, dynamic nature of the imaging modality with its ease of use and portability makes it the preferred diagnostic tool of choice, but still lacks the power of being a primary standalone tool. Further, its use as a therapeutic modality is being recognized as a form of management but cannot be used as a standalone modality; be it in diagnostic or therapeutic form.

Source of Support

NIL.

Conflicts of Interest

NIL.

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