Role of Ultrasonography in Dermatology

Essay

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بسم الله الرحمن الرحيم

وأنزل الله عليك
الكتاب والحكمة
وعَلَّمَكَ مَا لَمْ تَكُن
تَعْلَمُ وكَانَ فَضْلُ
اللَّهِ عَلَيْكَ عَظِيماً

صدق الله العظيم

سورة النساء الآية (١١٣).

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List of Abbreviations

AA	: Alopecia areata
CT	: Computerized tomography
FDA	: Food and drugs administration
NMSC	: Non melanoma skin cancer
SC	: Stratum cornium
SENEB	: Sub Epidermal Non Echogenic Band
TGC	: Time Gain Compensation
UAL	: Ultrasound- assisted liposuction
UBM	: Ultrasound Biomicroscopy
US	: Ultrasonography

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Introduction

The principle of ultrasonic imaging relies on the properties of reflected measure skin thickness, searching for the presence of foreign bodies in the soft-tissue traumatic wound, evaluating the inflammatory skin diseases and estimating tumor volume in non - melanoma skin cancer ***(Ulrich and Voit, 2001).***

The major advantage of this technique is its non – invasive non ionizing nature of examination and its relatively low cost when compared to X-ray, computerized tomography (CT) and scintigraphic techniques ***(Serup et al., 1995).***

The equipment consists of an ultrasound probe (hosting transducer), an elaboration, and a visualization system.The probe emits ultrasound waves which are transmitted into the tissues, where they are reflected or refracted following the optical laws. These events occur at interfaces between structures of different acoustic impedance,and the returning echo is analyzed and displayed on the monitor of the machine ***(Serup et al., 1995).***

**Types:

- Conventional ultrasound: image tissues with stationary interfaces.
- Doppler ultrasound: monitors tissues in motion, i.e, blood flow.
  - Pulsed wave Doppler.
  - Continuous wave Doppler.
  - Duplex ultrasonography.

- Ultrasound elastography:used to calculate the degree of elasticity of the tissue.

  - Evaluation of prostate, breast, thyroid, and liver masses, as well as general lymphadenopathy.
  - Differentiate between benign and malignant tumor.

Types of conventional ultrasound:

a- Low frequency:

-is used to visualize larger, deeper stractures, such as internal organs.

b- High frequency:

-High-frequency sonography using a 20-MHz transducer renders important preoperative information about the tumor size and especially about the tumor thickness in different skin tumors including cutaneous melanoma, basal cell carcinoma, and squamous cell carcinoma.

-the higher the frequency of the sound waves emitted by the trasducer, the clearer the picture, or the resolution.

-there is a trade-off between the clarity of visualization of proximal tissue and the depth of tissue penetration ***(Rallan and Harland, 2003).***

Applications:

Diagnostic and therapeutic purposes: #Diagnostic purposes: In recent years, ultrasound scanning has become an important diagnostic tool in dermatology. It provides an important diagnostic information in the following:

- Skin cancer.

- Inflammatory diseases, infectious diseases, benign neoplasms.

- Ultrasound has been applied to quantify facial aging

(Ulrich & Voit, 2001).

Therapeutic purposes:

-Ultrasound- assisted liposuction (UAL).

-Liporeduction.

-Nonablative rejuvenation of the face and neck ***(FDA, 2009).***

-Phonophoresis.

-Debridment of chronic wounds (using 25-KHz) acoustic waves.

-Ultrasound guided techniques in;

-Evacuation

-Aspiration

-Surgical excision ***(Fujimura et al., 2008).***

Aim of the Study

The aim of this work is to focus on the different applications of ultrasound in the field of dermatology.

Chapter (1):
Nature of Ultrasonography

Introduction

Ultrasound was introduced to medicine by Gohr and Wedkind and the neurologist Dussik. The pulse-echo technique, inaugurated by Firestone was first applied to medical diagnosis by Ludwig and Struthers in 1949for detection of gallstones ***(Holmes et al., 1965).***

Development of ultrasonography:

➢ ***Historical Aspect:***

While many creatures used ultrasound for many thousands of years, it was not until 1880 when the Curie brothers discovered the piezoelectric effect that the basis was created for the harnessing of ultrasound by man. Prompted by the sinking of the Titanic, the German physicist Behm in 1912 invented the echo-ranging process, which was used for submarine detection in the First World War ***(Wells, 1966).***

Ian Donald developed the first two-dimensional ultrasound contact scanner that did employ a water path. The transducer was applied to the body surface using an oil film as a coupling medium ***(Merz, 1996).***

In 1967, Krause and Soldner of Germany developed the first ultrasound scanner for real-time sectional imaging. This instrument permitted the observation of dynamic processes such as fetal body movements, heart activity, and breathing movements and it was the first machine with gray scale capability. Real-time sonography achieved a breakthrough with the development of multielement scanner introduced at the second European ultrasound Congress in Munich, 1975 with their enhanced resolution, ease of handling and lower cost ***(Merz, 1996).***

In the late 1970s, Alexander and Miller used high frequency ultrasound (15 MHz) to generate uni-dimensional scans of the skin. Much progress in the development of high frequency scanners has occurred since then, leading to the introduction of the first 20 MHz scanner. The equipment currently available allows both two and three dimensional imaging of the structures of the skin in vivo ***(Jemec et al., 2000).***

Now the role of ultrasound in dermatology has expanded, whether searching for the presence of foreign bodies in soft-tissue traumatic wound, evaluating the inflammatory response to a patch test, or estimating tumor volume in non melanoma skin cancer (NMSC), techniques in ultrasound are currently being refined to provide an extraclinical hand, especially as an adjunct to surgical exploration.

Nature of ultrasonography:

For a long time, the diagnosis of different dermatological diseases has been carried by brief history taking, inspection of the lesion and occasionally palpation without any further investigatory tools. In the last century, histopathological assessment became the gold standard for most dermatological diagnoses. But, the somewhat invasive nature of skin biopsy and the fact that not all lesions are amenable to definitive histological diagnosis, increased the need for other less invasive techniques. In this respect ultrasound seems to be a very promising tool for diagnosis and follow up of treatment of different of skin diseases. The major advantages of this technique are its non invasive, non-ionizing nature and its relatively low cost when compared to x-ray, CT and scintigraphic scanning techniques ***(Serup et al., 2007).***

The word sonography comes from the Latin word sonus (sound) and the word graphein (to write). Sonography (more precisely, ultrasonography) means imaging with ultrasound. An ultrasound image is the visible counter part of an invisible object produced by an electronic instrument ***(Zagzebski, 1983).***

To understand nature of ultrasound, it is important to realize that ultrasound is a sound with special properties and so we have to revise physical properties of sound ***(Machet et al., 2006).***

A sound wave is a mechanical disturbance propagating through a medium, either liquid, gas or solid. Sound waves are produced by vibrating sources that are in contact with the medium. Vibrations of the source produce vibrations of adjacent molecules in the medium, which in turn produce vibrations of more distal molecules, and so forth. The acoustic disturbance propagates away from the source at the speed of sound in the medium. Wave propagation results in energy transmitted through the medium, but with no net displacement of particles in the medium ***(Meire and Farrant, 1995).***

Different tissues reflect these waves distinctively, based on intrinsic variations in tissue structures, notably vascularity and density, which reflect differences in keratin, collagen and water content. These variations make ultrasound an important tool in assessing borders and interfaces between regions, eg, between the hypoechoic subcutis and the echogenic dermis, and between the hypoechoeic neoplasm and hyperechoic stroma. Ultrasound measurement entails the transformation of sound waves into visual images; and B-mode scanning, the method of choice in dermatology, translates the reflected waves into, brightness, value on the gray scale, which are then viewed on the monitor. Low-frequency and high-frequency ultrasound are used in different purposes. Low-frequency ultrasound is used to visualize larger, deeper structures, such as internal organs. The superficial anatomy of skin structures and neoplasms are not visualized using low-frequency ultrasound. The higher the frequency of the sound waves emitted by the transducer, the clearer the picture, or resolution, of tissues closer to the transducer. The essential point is that there is a trade-off between the clarity of visualization of proximal tissue and the depth of tissue penetration by the sound wave. HFUS, sacrificing deeper spatial discrimination for more detailed superficial pictures has become the mainstay of ultrasonic application in dermatology in the last two decades. Practically speaking, 20- to 25-MHz ultrasound will allow the operator to see both the epidermis and dermis; 50-to100-MHz ultrasound only provides visualization of the epidermis ***(Marmur et al., 2010).***

Ultrasound Nomencloture:

- **Echogenic:** The ability of a structure to produce echo.
- **Anechoec:** No echoes and sonolucent, appears black on ultrasound.
- **Hypoechoic:** less reflective and low amount of echoes when compared with the neighboring structures, appears as varying shades of darker gray.