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INTRODUCTION OF ARTIFICIAL INTELLIGENCE IN MEDICAL EXAMINATIONS USING ACOUSTICS

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Annotation: Acoustic technologies are widely used in medical practice, ranging from diagnostic procedures to therapeutic treatment methods. This article discusses the main areas of use of acoustics in medicine, including ultrasound diagnostics, therapeutic methods and the latest developments in acoustic biomedicine. Special attention is given to the prospects of high-intensity ultrasound and its combination with other therapeutic methods.
Keywords: Ultrasound, liposuction, abdominal diagnostics, neurostimulation, biomedicine, therapy, drug delivery, HIFU.

Introduction: Acoustics plays an important role in modern medicine. One of the best known applications of acoustic technologies is ultrasound (US) which is used in diagnosis of diseases of internal organs, heart and vessels, as well as in obstetrics. However, the use of sound waves in medicine is not limited to diagnosis. Therapeutic methods such as high-intensity focused ultrasound (HIFU) are opening up new possibilities for treating tumors and other pathologies.
Ultrasonic diagnosis is based on the principle of reflecting high-frequency sound waves (usually from 1 to 15 MHz) from the tissues of the body. These reflected signals are converted into an image that helps the doctor visualize internal organs and tissue. US Ultrasound is widely used in various fields of medicine:
Obstetrics and gynecology: early pregnancy determination, assessment of fetal development, placental and amniotic fluid status, diagnosis of pathologies and doppler.
Cardiology: echocardiography allows to visualize the heart's work in real time, assess the condition of the heart valves and wall sizes.
Abdominal diagnosis: diagnosis of diseases of the abdominal organs (liver, kidney, gall bladder and pancreas etc.); determination of structure, size, shape and position of organs; detection of inflammations, edema, stones in the kidneys or in the gallbladder; Detection of vascular disorders.
Advantages and limitations of ultrasound
One of the main advantages of ultrasound is its non-invasive and safe for the patient, as the procedure does not use ionizing radiation as in X-ray or CT. However, the ultrasound has limitations - the visualization of bones and hollow organs is difficult, and accuracy may be reduced if the patient is obese.

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Therapeutic methods based on acoustics. High-intensity focused ultrasound (HIFU) is the latest therapeutic technology that uses high-intensity acoustic waves to non-invasive destruction of pathological tissues such as tumors. The advantage of HIFU is its ability to act on affected tissue with a spot without damaging healthy areas. HIFU is now being used extensively for the treatment of prostate tumors, liver and benign uterine neoplasms.

Lithotripsy is a medical procedure used to break down stones in the kidneys, urinary tract, bladder or gall bladder with shock waves. The main purpose of lithotripsy is to fragment large stones into small particles, which can then be easily removed from the body naturally. Its advantages are that it does not require surgical intervention and the patient is able to recover quickly.

Extracorporal Shock-Wave Lithotripsy (EVOL) is the most common method. The procedure is based on using shock waves that are generated outside the body and directed to the stone through the skin. Shock waves are created by a special generator (electrohydraulic, electromagnetic or piezoelectric). Waves are directed to a specific point where the stone is, by using an acoustic lens or reflector. The high energy of waves causes the formation of microcracks in the stone, which then gradually breaks down into smaller fragments. The particles are removed naturally through the urinary system. Suitable for treatment of stones up to 2 cm in the kidneys and upper urinary tract.

Benefits:

-No surgical incisions.

-patient can return to everyday life within a few days.

-widely used in urological clinics.

Laser lithotripsy is a modern, low-invasive method of removing stones from kidneys, urinary tract or bladder using laser (Golmiev, Tuleiev) energy. The procedure is carried out through natural pathways (urethra), without cuts. The doctor inserts a flexible endoscope through the urethra and moves to the location of the stone (in the kidney, bladder or bladder). The laser waveguide is attached to a rock and the laser energy breaks it into small fragments or turns it into dust ("dusting" technology). The fragments of stone are removed with special tools or are removed by themselves with urine.

Advantages: suitable for breaking all types and sizes of stones, laser acts exclusively on stone without damaging surrounding tissues, allows to reach hard-to-reach stones, such as in the lower scapes of the kidneys, "dusting" technology leaves minimal stone residue.

Percutaneous nefrothrothropy (PNI)

This is a minimally invasive surgical method of removing large or complex stones from the kidney. This method is used when other procedures, such as extracorporeal lithotripsy or laser crushing are ineffective. Through a small incision on the skin (up to 1 cm) and back tissue, the surgeon has direct access to the kidney. An x-ray or ultrasound is used to insert a tube into the kidney, providing access to the stone. The stone is broken down using ultrasonic, pneumatic or laser energy. The stone fragments are extracted through the created access with the help of a special endoscopic instrument.

Benefits:

-Allows for complete removal of the stone in one procedure.

-small incision reduces the risk of complications and recovery time.

-suitable for removing any type and size of stones.

-Access under the control of US or X-ray minimizes damage to healthy tissue.

. New directions and developments in acoustic medicine

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Acoustic biomedicine

One promising area is the use of acoustics for targeted drug delivery. Studies show that ultrasound can be used to temporarily increase the permeability of cell membranes, allowing drugs to be delivered to precisely defined areas of the body, minimizing side effects.

Acoustic stimulation of nerve cells

Ultrasonic neurostimulation is another new field that scientists are exploring. Acoustic waves can be used to affect nerve cells noninvasively, which can be used to treat neurological diseases such as Parkinson's disease and chronic pain.

4. Advantages and challenges of the application of acoustics in medicine

Safety and non-invasive

One of the main advantages of acoustic methods in medicine is their non-invasive and high degree of safety for the patient. These techniques minimize the risk of complications associated with surgery and do not require a long recovery period.

Limitations, problems and their solutions

Acoustic treatments in medicine are not entirely new, but however modern improvements, new applications and high-precision methods are still considered innovative and have a number of limitations and problems such as limited penetration of ultrasound into dense tissues, Interference and artifacts in images, tissue heating with prolonged exposure, difficulties in visualizing deep structures and side effects of ultrasound therapy.

Development of new technologies such as improved ultrasounds with enhanced sensitivity and adaptive focusing systems that can compensate for signal loss and use digital noise reduction signal processing, Signal filtering and adaptive correction can be a solution to limited penetration and interference.

Treatment using high-intensity focused ultrasound or lithotripsy can result in damage to neighboring tissues and pain. Improving the accuracy of ultrasound focusing with advanced guidance systems can prevent damage to neighboring tissues, and for patient comfort a combination with anesthesia or painkillers is used to eliminate the sensation of pain.

In medicine, artificial intelligence (AI) is also actively used to improve diagnosis, treatment and health monitoring, including various acoustic technologies. Here's how AI is applied in the medical field:

Acoustic technologies for diagnostics

Hearing aids: Acoustics play an important role in the diagnosis of cardiovascular diseases such as heart or lung disease. AI helps to automatically analyze the sounds obtained with stethoscopes. It can recognize abnormal sounds (such as heart or lung noise) and alert the doctor about possible problems, such as heart noise, inflammation of the lungs or bronchitis.

Breath sound analysis: AI can be used to analyze sounds emitted by the respiratory tract for diagnosis of lung diseases such as asthma or chronic obstructive pulmonary disease (COPD). AI can highlight key sound features that help doctors make a diagnosis.

Voice diagnostics and monitoring

Voice analysis for disease detection: AI can analyze a person's voice to detect early signs of disease such as Parkinson's or depression. Changes in the voice (e.g., speech retardation, achiness or a change in tone) can be indicators of disease, and AI may automate this process for earlier diagnosis.

Patient condition monitoring: AI-based systems can track changes in the patient's voice to monitor diseases such as COVID-19 or cold, and to track recovery progress after surgery or treatment.

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Medical sound data processing
Processing and analyzing medical images using acoustics: modern methods such as ultrasound are widely used in medicine for imaging internal organs. AI helps in the automatic analysis of ultrasound images, improving diagnostic accuracy and reducing the likelihood of errors.
Ultrasound diagnostics using AI: AI helps to improve ultrasonic technologies by analyzing acoustic waves passing through tissues and detecting anomalies such as tumors, clots or other pathologies.
Acoustic biomarkers
Acoustics as a means of detecting biomarkers: the use of acoustic technologies and AI allows to detect biomarkers - molecules that indicate the presence of diseases such as cancer. For example, AI can analyze the sound emitted by cells or tissues to identify specific biomarkers.
Listening and speaking systems
Hearing aid and implant improvement: AI is actively used in hearing aids to adapt sound to the environment. This improves the quality of life of patients with hearing impairments, as AI can automatically adjust sound amplification, filter noise or
Speech restoration with AI: AI is used to restore speech in patients with disorders such as aphasia after a stroke or injury. AI helps to analyze the sound patterns and restore normal speech, as well as adapt technology to individual needs.
Forecasting and early diagnosis
AI can use acoustic data to predict disease, for example based on changes in the sounds of breath or voice. This allows for early detection of diseases when they are easier to treat.
Therapy and treatment with sound waves
Sound wave therapy: AI is also used to create and control therapeutic sound waves, for example for treating chronic pain, recovering from injury or treating inflammation. Techniques such as shock-wave therapy or acoustic stimulation can be improved with AI, which adapts the frequency and strength of waves for the most effective treatment.
Conclusion: the use of acoustics in medicine is one of the most promising areas, which is already widely used in diagnosis and therapy, And the introduction of artificial intelligence opens up more doors to acoustic technology, providing more accurate and correct data for further functionality. Technologies such as HIFU and lithotripsy have already proven their worth, and new developments such as acoustic drug delivery and neural stimulation are opening up new horizons for medical practice. However, further research to improve accuracy and safety is needed to further develop acoustic methods.

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