Assignment 5

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Fields and waves

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What possible health hazards of static magnetic fields? (List at least 5)

1. Increased risk of lung and bladder cancer
2. Increased risk of spontaneous abortions
3. From 2T, effects such as nausea, vertigo and metallic taste in the mouth may appear
4. Above 8T, a reversible modification of the electrocardiogram is possible
5. Passive implants (screws, pins, etc.) and ferromagnetic foreign bodies (shrapnel, etc.) can move in the body
6. Active implants such as pacemakers, defibrillators and other neurological stimulators may experience electrical and / or electronic dysfunctions. The same problem may also arise for Insulin pumps

Explain the theory and uses of the following:

Iontophoresis

Usage:

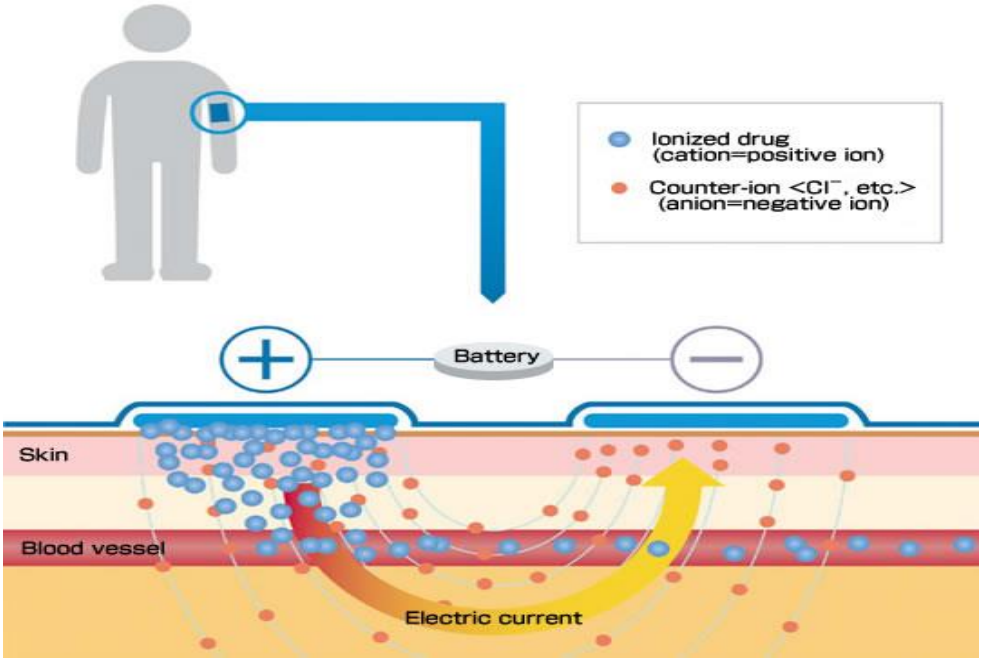
Phoresis (transfer) of ions - also called Electromotive Drug Administration is a technique which uses an electric current to deliver a medicine or other chemical through the skin (basically an injection without needle).

Principle:

In a typical Iontophoretic drug delivery system we can find an anode (a positively charged chamber), a cathode (a negatively charged chamber) and two reservoirs, one that has the drug (the active agent) and another one containing bio compatible salts (the vehicle) however both the active agent and the salt have to have the same (positively or negatively) charge as the chamber they are in.

There are two types of Iontophoresis according to the charge of ion to be delivered the anodal and cathodal iontophoresis. In anodal Iontophoresis the cationic therapeutic agents and the salts are placed under the anode in the desired site on the skin while the cathode in placed somewhere else on the skin while in cathodal Iontophoresis they are placed in the opposite way.

When a low voltage current is applied in the chamber with the contends and once, they all have the same charge they will repel into the skin by the pores. Then the bio compatible salt will pass to the opposite electrode forming the electric current direction and the drugs will pass trans dermal. The number of ions that penetrate are directly proportional to the applied current, as we are applying the charge the skin permeability will increase and the ions will easily migrate into the epidermis.



Neuromuscular stimulation

Usage:

Neuromuscular stimulation refers to the use of low-level electrical current to produce a muscle contraction. It's used in cases of neurological injury that result in muscle paralysis or paresis. Clinical applications of NMS provide either a therapeutic or functional benefit.

Principle:

Electrical current, applied to excitable tissue through a pair of electrodes, creates a localized electric field that depolarizes the axonal membranes of nearby neurons. If the depolarization reaches a critical threshold, an influx of sodium ions from the extracellular space to the intracellular space produces an action potential that propagates from the site of stimulation and has the same effect as a naturally generated action potential. When the action potential reaches the terminals of the axon, neurotransmitter is released and, in the case of motor neurons, muscle fibers contract.

NMES systems generally operate by activating motor neurons rather than the muscle directly, even though NMES is commonly referred to as "muscle stimulation." It is easier to stimulate a nerve than a muscle.

The strength of a muscle contraction produced by NMES can be modulated by manipulating three stimulus parameters that characterize the wave of current pulses: pulse frequency, amplitude, and duration.

Transcutaneous nerve stimulation

Usage:

Transcutaneous electrical nerve stimulation (TENS) is a therapy that uses low voltage electrical current to provide pain relief. A TENS unit consists of a battery-powered device that delivers electrical impulses through electrodes placed on the surface of your skin. The electrodes are placed at or near nerves where the pain is located or at trigger points.

Principle:

There are two theories about how transcutaneous electrical nerve stimulation (TENS) works.

- One theory is that the electric current stimulates nerve cells that block the transmission of pain signals, modifying your perception of pain.
- The other theory is that nerve stimulation raises the level of endorphins, which are the body's natural pain-killing chemical. The endorphins then block the perception of pain.

What is 'MAGNETOM Terra', its advantages, and possible safety issues?

MAGNETOM Terra is the first 7T MRI scanner for diagnostic imaging and is designed for unprecedented breakthroughs in clinical care.

Advantages:

- The unique Dual Mode lets you switch between clinical and research operations, with separate databases to distinguish between clinical and research scans. This advanced ultra-high-field (UHF) technology is at the cutting edge of MRI.
- MAGNETOM Terra lets the physician go deeper than ever before. All in one, the power of 7T MRI helps deliver previously unseen insights that could improve patient outcomes.
- Double SNR for more precision – With clinical applications in Dual Mode
- A 0.2 mm in-plane resolution to visualize previously unseen structures
- 0.14 cm^3 voxel sizes for higher resolution.

Possible safety issues:

- For 7-T MRI, stronger electromagnetic fields cause greater forces on metallic devices, increased potential for functional deficiency of active implants, and unpredictable radiofrequency heating due to the current lack of single-channel body radiofrequency transmit coils and the shorter resonant wavelength relative to lower magnetic field strengths.

- In a study of more than 3000 patients imaged with 7-T MRI, nystagmus, nausea, motion disturbances, dizziness, and other bioeffects were shown to be of some concern, with 38% of patients reported vertigo, 5.4% reported electro gustatory effects (metallic taste), and 1.2% reported magneto phosphenes (perceived flashing lights).

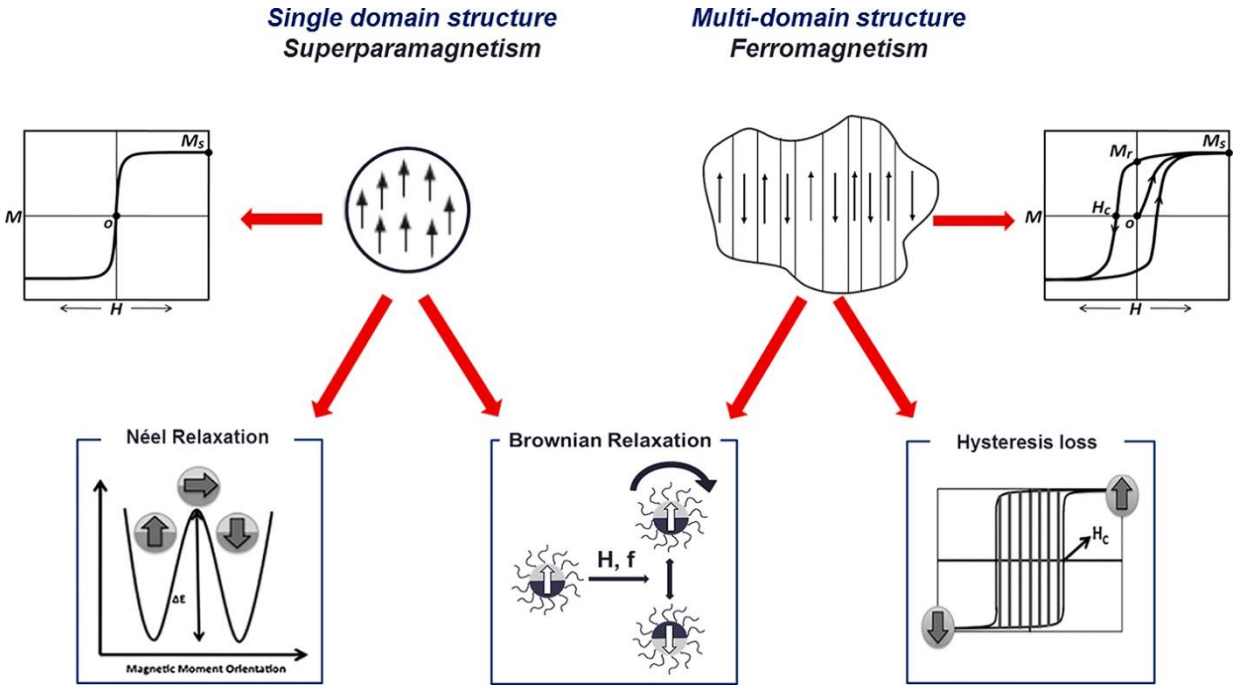
Describe two applications of ferromagnetic materials in therapy.

The material is ferromagnetic nanoparticles.

- Ferromagnetic nanoparticles for hyperthermia and thermo-ablation therapies.

  Hyperthermia directed specifically to cancer cells through the use of magnetic nanoparticles heated with alternating magnetic fields has been used as a novel cancer therapy. This paper will explore this new application of magnetically-induced hyperthermia in cancer therapy.

  The use of magnetic nanoparticles for hyperthermia has shown great promise in the field of disease treatment. By raising the temperature of tissues to between 42 ° C and 46 ° C, the viability of the disease tissues is reduced and their sensitivity to chemotherapy is increased. In addition to selectively killing tumor cells, a potential of developing antitumor immunity after hyperthermia treatment has been also suggested.



- Ferromagnetic nanoparticles for drug release.

The magnetic nanoparticles have been widely used for targeted delivery and controlled drug release due to their response to a magnetic field.

The functionalized magnetic nanoparticles could carry other active targeting moieties, drugs and imaging agents by both physical interactions and covalent linkages.

A controlled drug delivery system should be able to deliver drugs to a targeted location in the body, and to maintain drug levels within the required concentration range for therapy. A high-gradient of external magnetic fields could be used to guide and concentrate the magnetic nanocarriers at targeted site in order to reduce the systemic distribution of cytotoxic compounds, and to enhance drug uptake, resulting in more effective treatment at lower doses.