ULTRASOUND THERAPY

PHYSICAL & PHYSIOLOGICAL EFFECTS

As oscillation or sonic energy is passed through the body tissue, it causes transfer of heat energy in the body tissues. If this energy is not dissipated by normal physiological response, then there is local rise in temperature, which accounts for thermal effects. If heat dissipation equals heat generation there is no net rise in temperature and any effects are said to be non-thermal. Using low intensities or pulsing the output achieves non-thermal effects.

Thermal effects

The advantage of using ultrasound to achieve heating is due to the preferential heating of collagen tissue and to the effective penetration of this energy to deeply placed structures. Heating fibrous tissue structures such as joint capsules, ligaments, tendons, and scar tissue may cause a temporary increase in their extensibility, and hence a decrease in joint stiffness. Mild heating can also have the effect of reducing pain and muscle spasm and promoting healing processes**.**

Non thermal effects

Cavitation: • Cavitation is the formation of tiny gas bubbles in the tissues as a result of ultrasound vibration. These bubbles, generally of a micron (10-6 m) diameter. These can be of two types, namely stable cavitation or transient(non-stable) cavitation.

Stable cavitation occurs when the bubbles oscillate to and fro within the ultrasound pressure waves but remain intact.

Transient (or collapse) cavitation occurs when the volume of the bubble changes rapidly and then collapses causing high pressure and temperature changes and resulting in gross damage to tissues.

Stable cavitation associated with acoustic streaming, is considered to have therapeutic value but the transient cavitation, which is only likely to occur at high intensities, can be damaging.

In practice the danger of tissue damage due to cavitation is minimized by the following measures: Using space-averaged intensities below 4W/cm2 • Using a pulsed source of ultrasound • Moving the treatment head during treatment

References:

• Agents in Rehabilitation, From research to practice; Michelle H. Cameron, 2nd Edition
• Electrotherapy Explained, Low, J. & Reed, A, 4th Edition.

Acoustic streaming: Acoustic streaming is a steady circulatory flow due to radiation torque. Additionally, as a result of either type of cavitation there is a localized, unidirectional fluid movement around the vibrating bubble. These very small fluid movements also occur around cells, tissue fibres, and other boundaries, which is known as **microstreaming.**

Microstreaming exerts stress on the cell membrane and thus may increase membrane permeability. This may alter the rate of ion diffusion causing therapeutically useful changes, which includes increased secretion from mast cells, increased calcium uptake, and production of macrophages. All these effects could account for the acceleration of repair following ultrasound therapy.

Standing waves:- Standing waves are due to reflected waves being superimposed on the incident waves. The result is a set of standing or stationary waves with peaks of high pressure (antinodes). Gas bubbles collect at the antinodes, and cells collect at the nodes. This pressure pattern causes stasis of cells in blood vessels. The endothelium of the blood vessels exposed to standing waves can also be damaged leading to thrombus formation. There is also the possibility of marked local heating where the amplitude of the combined waves is high. If transducer head is moved during the treatment, then standing waves are unlikely to form.

Micromassage:- • The micromassage effect of ultrasound occurs at a cellular level where the cells are alternately compressed and then pulled further apart. The waves of compression and rarefaction may produce a form of micromassage, which could reduce oedema. Ultrasound has been found to be effective at reducing recent traumatic oedema and chronic indurated oedema.

EFFECT OF ULTRASOUND ON WOUND HEALING

Acute stage:- • Stable cavitation and acoustic streaming increases calcium ion diffusion across the cell membrane, which works as a cellular 'secondary messenger', and thereby increases the production and release of wound-healing factors. These include the release of histamine from mast cells and growth factors released from macrophages. In this way, ultrasound has the potential to accelerate normal resolution of inflammation providing that the inflammatory stimulus is removed.

References:

• Agents in Rehabilitation, From research to practice; Michelle H. Cameron, 2nd Edition
• Electrotherapy Explained, Low, J. & Reed, A, 4th Edition.

This acceleration could also be due to the gentle agitation of the tissue fluid, which may increase the rate of phagocytosis and movement of particles and cells. Thus, ultrasound has a pro-inflammatory, not an anti-inflammatory action.

Proliferative (Granulation) stage:- • This begins approximately 3 days after injury and is the stage at which the connective tissue framework is laid down by fibroblasts for the new blood vessels. During repair, fibroblasts may be stimulated to produce more collagen; ultrasound can promote collagen synthesis by increasing cell membrane permeability, which allows the entry of calcium ions, which control cellular activity.

Not only is more collagen formed but it is also of greater tensile strength after ultrasound treatment. Ultrasound encourages the growth of new capillaries in chronic ischaemic tissue and the same could happen during repair of soft tissues after injury. The enhanced release of growth factors from macrophages following exposure to therapeutic ultrasound may cause proliferation of fibroblasts.

It has been suggested that ultrasound treatment given during the first 2 weeks after injury accelerates bony union, but, if given to an unstable fracture during the phase of cartilage formation, it may result in the proliferation of the cartilage and consequently delay of bony union.

Remodelling Stage:- This stage last months or years until the new tissue is as near in structure as possible to the original tissue. Ultrasound is considered to improve the extensibility of mature collagen such as is found in scar tissue, which occur by promoting the reorientation of the fibres (remodelling), which leads to greater elasticity without loss of strength.

THERAPEUTIC USES

Varicose Ulcers: Ultrasound promotes healing of varicose ulcers and pressure sores (decubital ulcer.

Pressure Sore

Pain relief: • Ultrasound is used in low backache, prolapsed intervertebral disc (PIV) and many other conditions.

References:
• Agents in Rehabilitation, From research to practice; Michelle H. Cameron, 2nd Edition
• Electrotherapy Explained, Low, J. & Reed, A, 4th Edition.

Acute tissue injury:- • Ultrasound is used in soft tissue and sport injuries, in occupational injuries and post-natal injuries. It is used for perineal post-natal pain, for painful shoulders and for both neurogenic & chronic pain.

Scar Tissue:- • Ultrasound improves quality of scar tissue and excessive fibrous tissue. It is used in conditions like Dupuytren's contracture and plantar fasciitis.

Bone injury:- • Ultrasound therapy in the first 2 weeks after bony injury can increase bony union, but, given to an unstable fracture during the phase of cartilage proliferation, it may result in the proliferation of cartilage and therefore decrease bony union. Ultrasound has also been used in the early diagnosis of stress fractures. Chronic Indurated Oedema: The mechanical effect of ultrasound has an effect on chronic oedema and helps in its treatment. It also breaks down adhesions formed between adjacent structures.

CONTRAINDICATIONS

Tumors – it might encourage neoplastic growth and provoke metastases or over precancerous tissue should be avoided

Pregnant Uterus – avoid applying ultrasound over a pregnant uterus, probable risk to the rapidly dividing and differentiating cells of the embryo and fetus

Epiphyseal plates – avoid giving ultrasound over epiphyseal plates as growth of the bone is impeded

Spread of Infection - Bacterial or viral infection could be spread by ultrasound, presumably by facilitating microorganism movement across membranes and through the tissues. The low-grade infections of venous ulcers, or similar, would seem to be safe to treat. Tuberculosis - Due to the possible risk of reactivating encapsulated lesions tuberculous regions should not be treated.

Vascular Problems- Circumstances in which hemorrhage might provoke should not be treated. For example, where bleeding is still occurring or has only recently been controlled, such as an enlarging haemarthrosis or haematoma or uncontrollable haemophilia.

Severely ischaemic tissues should be avoided because of the poor heat transfer and possible greater risk of arterial thrombosis due to stasis and endothelial damage.

References:

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• Electrotherapy Explained, Low, J. & Reed, A, 4th Edition.

Treatment over recent venous thrombosis might extend the thrombus or disrupt its attachment to the vein wall forming an embolus. Areas of atherosclerosis are best avoided for the same reason

Haemarthrosis: Bleeding into the joint usually from an injury, which results in a swelling of the joint, is known as haemarthrosis.

Haematoma: A collection of blood inside the body, caused by bleeding from an injured vessel is called haematoma.

Haemophilia: An inherited coagulation defect characterized by a permanent tendency to hemorrhages due to a defect in the coagulation of blood is known as haemophilia.

Atherosclerosis: A condition caused by intramural deposition of Low Density Lipoprotein (LDL), secondary to exposure of smooth muscles to lipid, resulting in platelet induced smooth muscle proliferation, formation of fibrotic plaques and calcification is known as atherosclerosis

Radiotherapy - Areas that have received radiotherapy in the last few months should not be treated because of the risk of encouraging pre-cancerous changes.

Nervous System - Where nerve tissue is exposed, e.g. over a spina bifida or after a laminectomy, ultrasound should be avoided. Treatment over the cervical ganglia or vagus nerve might be dangerous in cardiac disease.

Specialized Tissue - The fluid-filled eye offers exceptionally good ultrasound transmission and retinal damage could occur. Treatment over the gonads is not recommended.

Implants - Smaller and superficial implants, like metal bone-fixing pins subcutaneously placed; as a precaution, low doses should be used in these circumstances.

Treatment over implanted cardiac pacemakers should not be given because the sonic vibration may interfere with the pacemaker's stimulating frequency

Anaesthetic areas - High doses should not be given over anaesthetic areas.

DANGERS OF ULTRASOUND:

There are very less evidences of dangers of ultrasound but it may occur in some conditions only.

Burns could occur if the heat generated exceeded the physiological ability to dissipate it.

Tissue destruction would result from transient cavitation.

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• Electrotherapy Explained, Low, J. & Reed, A, 4th Edition.

Blood cell stasis and endothelial damage may occur if there is standing wave formation.

These dangers would be more likely with high-intensity continuous output with a stationary head or over bony prominences

References:
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• Electrotherapy Explained, Low, J. & Reed, A, 4th Edition.