‘Therapeutic Magnetism in

Medical and Veterinary Practice’,

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Section Headings

Note:- Abbreviations used

MT - Magnetic therapy

PMT - Pulsed magnetic therapy

IHD - Ischaemic heart disease

MS - Multiple Sclerosis

MRI - Magnetic resonance Imaging

Introduction.

Often having been regarded as 'fringe medicine' pulsed magnetic therapy (PMF) is gaining increasing attention from the medical world. Predominantly its use had been in the field of orthopaedics. This primarily related to the use of magnetic fields to fracture union. However, criticism was raised that research lacked rigour and that controlled, double blind trials were needed to justify the claims made for its efficacy. There is evidence that this has been addressed, and a number of papers have been published as a result. For example, Sharrard[1] has presented the results of a double blind trial carried out on clinical and radiologically identified cases of delayed union. The research, carried out at the Royal Hallamshire hospital, Sheffield, records that significant results were achieved using pulsed magnetic therapy. Taking a broader approach to its use in orthopaedics, Trock[2] was among those investigating the successful application of PMF for the treatment of osteoarthritis of the knee and cervical spine.

Increasing research began to appear from Japan in the late 1950's. Interest in pulsed magnetic therapy had been encouraged as it became apparent that it had the potential to be an invaluable tool in a much wider range of clinical applications. There were a number of medical congresses on magnetism, with three focusing on magnetic fields and living bodies held between 1974 and 1976. Lightwood[3] (1989) referred to the successful use of pulsed magnetic therapy in the following instances:

a) circulatory disease of lower limbs

b) oedema

c) bronchial oedema

d) pain relief

e) deep vein thromboses

f) dental pain

Research continues in the U.K, France, China, Canada, Japan and the USA, where as recently as 1970, the American government began funding new research at Florida State University. In Eastern bloc countries, the position was different. Studies have investigated the effect of pulsed magnetic fields on a wide range of conditions including asthma, heart failure and cancers. These studies show evidence of alleviation of symptoms, particularly when used in conjunction with other treatment regimes such as drugs and physical therapy. Pulsed magnetic therapy has been used widely due to its low cost in times of financial

restraint and ease of application at a time of increasing locomotor disease. Furthermore, the treatment is well tolerated by patients of all ages.

Changes in political climate have enhanced communication and dissemination of information, so that details of this research are now becoming available to the western world. There is a wealth of data now available and this report can give only a brief outline of the research undertaken.

Properties of Magnetic Fields

There are 3 types of magnetic field: -

a) Sinusoidal b) Pulsed c) Static.

All three types have been employed in carrying out clinical investigations, with a number of studies comparing the efficacy of static and pulsed fields. Sinusoidal fields have also been included in trials.

Sinusoidal field.

This type of field rises and falls about a zero point. An AC current through a solenoid produces it. In essence, as the current increases and decreases with each change in direction of flow, so the field rises and falls, and the polarity reverses. In actual fact, the field is more related to the shape of the waveform applied to the coil. The coil modifies the waveform to generate a field that is not a true sinusoidal field.

Pulsed Magnetic field.

This type of field is switched on and off at a base frequency rate (i.e. 50Hz or 200Hz). It is supplied with a square waveform signal. Again, the coil modifies the waveform and gives out a pulsing magnetic field which follows a saw tooth type pattern. Pulsing of this base frequency at rates of say 5 to 25 times a second allows the field to be switched on and off in 'packages'. This pulsing of the base frequency has differing biological effects depending upon the rate.

Static field.

This can emanate from a permanent magnet or be produced by a coil carrying a D.C. current. The field's intensity depends on the magnitude of the current through the coil or, in the case of a permanent magnet, the density of the material and the degree of alignment of the domains.

Interaction Mechanisms.

Experiments into medical applications of pulsed magnetic therapy have been shown to include: -

a) an analgesic effect

b) resolution of soft tissue damage

c) enhancement of fracture union.

In each case, this is due to interactions between the pulsating magnetic field and tissue at the cellular level. An insight into these mechanisms was discussed in more detail in a paper published in the OCPPP journal (Laycock[4] 1996) On the basis of further research, it is now possible to look at this at the sub atomic level.

Three categories of action have been identified.(Jerabek[5] 1996) Firstly, electro-magnetic induction is produced. This is the key mechanism for interactions between magnetic fields and tissue. This can be viewed as essentially the same as any electro-magnetic induction process in that charged particles (cations and anions and including electrons) are caused to move by a dynamic inducing field thus causing a flow of current. This applies to both pulsed and static fields, the mechanism for this being relative movement between field and tissue. This is of greater significance with a pulsed field than with a static field. (Special consideration of static fields is given later.)

The other two features of interactions are of lesser importance in considering biological effects.

a) Specific molecules (diamagnetic and paramagnetic molecules) may change their orientation due to the applied field. This effect applies principally to extremely strong static fields such as in a MRI scanner and is of lesser importance therapeutically.

b). At the subatomic level, magnetic fields can have an influence on spin states of electrons.

Measuring Magnetic Field Strength

Tesla - This is the largest unit. This strength is not commonly used in medicine.

Gauss - 1 G = 10-4 tesla A great deal of research is operating in ranges of 100G or less.

Picotesla - One p = 10-12 T or 10-8G this measurement is commonly used for very low emission devices. Experiments with this strength have been predominantly in the area of neurology e.g. multiple sclerosis

Static Fields

There has to date been no scientifically proven value of static fields, however, the following suggested interactions may provide a minute cellular effect due to: -

a) Bodily movement between the static magnet and biological tissue.

b) Blood flow- venous, arterial and capillary flow*

c) Thermal agitation of cells within the area of the applied field

Any relative movement in a) and b) would be extremely low when compared to those of pulsating fields. In terms of c, the amount of vibration due to heat is at a microscopic scale, although the frequency may be higher. If comparison is made between the effects of a pulsed field as against a static field of similar field strength, the effect of the static magnet will, therefore, be minimal. It would be necessary to have a far more intense field over a longer period of time for static fields to be effective if at all.

The initial advantage of a pulsed field is that the frequency can be pre-set to get the optimum effect for a specific condition by a combination of base frequency and pulsating frequency.

However, static fields provide a 'fix and forget' form of therapy static which may be left on the injury for a prolonged period of time but of doubtful value. This may allow any slower interaction to take effect along with the natural rate of healing..

The question of polarity.

The field emanating from a static magnet is a closed loop that will follow the easiest path, flowing from North to South. The actual magnetic flux does not change in character in its transit. The difference within the field pattern is that of intensity. In free space, its density exterior to the magnet itself will be highest at the poles, the two being equal since what leaves at the north is exactly equal to that entering at the south. There is no net outflow from the system, hence the name static.

Where magnetic material is placed exterior to the magnet, but within the field pattern, the flux will take the easiest path and may be distorted to pass through that material on its way back to the magnet's south pole. Biological material has virtually no effect on the path of the field but when placed in the field will see different directions of flow, depending on the orientation of the field at that point. Thus cellular material will be subjected to a flow in one direction as the field enters the material, but the reverse as it leaves. So, both polarities will be seen to exist. The argument for N or S pole having differing effects for different conditions is difficult to comprehend since the only change in the nature of the field is its density, regardless of the direction of flow.

A number of claims have been made regarding the different actions of north versus south poles of magnets in relation to therapy. Some reports have suggested that the north pole of a magnet has antibiotic properties, while the South Pole has energy giving properties. However, after consideration of a significant range of scientific reports and analysis of research presented at the First World Congress in Magnetotherapy[6] (1996) it was concluded that, with few exceptions, there was no firm evidence to support the idea that polarity is of specific significance.

Effects of magnetic fields on Blood flow

The question arises as to whether any magnetic field pulsed or otherwise could affect blood flow directly. Static magnetic therapy companies claim that somehow when iron in blood is subjected to, and passes through the field as it is mounted on, say, a wrist, then the blood is caused to be agitated and as such somehow becomes more oxygenised. Some manufacturers cause the field to appear reversed i.e. present the opposite static polarity along the flow of blood underneath the 'watch' or magnetic pad, claiming this is more effective. Non of these claims can have any basis in fact as the iron in blood only exists in an ionic form which has electrostatic static but no magnetic properties.

The numbers of iron ions in blood are vast, some 280 million haemoglobin molecules exist within every red blood cell of which there are 4.8 to 5.6 million red blood cells per cubic millimetre. Each haemoglobin molecule contains 4 haems (Fe^{2+}), which hold the ferric ions that easily combines with oxygen to become $Fe^{2+} + O^{2-}$ through static attraction and combination, in the lungs to transport it around the body, and carbon dioxide ($Fe^{2+} + CO^{2-}$) from muscles and other organs to be returned to the lungs. The movement of blood in the veins is at a rate of up to 2 meters per second and it is this movement that it is claimed to be affected by a magnetic field. It is true that when electrons or ions are caused to move then they develop magnetic field properties, but the speed at which this occurs is only at that approaching the speed of light (300 million metres per second). Clearly the very slow speed

of blood flow would be such that any deflections caused by any interactions with static magnetic fields are zero to all intents and purposes.

Veterinary Use

Many trainers, animal therapists and some veterinary surgeons accept the use of pulsed magnetic therapy with animals. Here too, its use is primarily to enhance fracture union, for other orthopaedic problems such as sprains, ligament injuries and for soft tissue injuries. Magnetic therapy has been recommended over other methods for relieving a range of equine problems (Bromley[7] 1993). It is its effectiveness at enhancing and accelerating the healing process in this type of injury that has made magnetic therapy so popular with trainers and owners in the equine and greyhound field.

As in clinical medicine, the idea of using pulsed magnetic therapy for other conditions is less recognised. However, if the equipment is in the hands of a trained professional, able to select an appropriate method, duration of treatment and frequency, magnetic therapy can help to improve other conditions including enhancing the absorption of nutrients and improvement of blood flow. Cases are recorded where pulsed magnetic therapy used in conjunction with other conventional treatments can bring about recovery, whereas conventional medical treatments alone had been ineffective. (Scott[8] 1995)

In the sphere of research, there is a long history of, and wide range of, animal experimentation. In a number of cases, these experiments often confirm, in more controlled conditions, the main effects seen in clinical practice. Such experiments are, however, more frequently conducted with a view to advancing human medicine than veterinary medicine, with unfortunate consequences for the subjects. Animal experiments constantly prompt the question of whether the results can with certainty be extrapolated to humans, and vice versa. There are cases where animals are able to tolerate without adverse effect some treatments that humans cannot. Equally there are instances where the reverse is true.

Animal Experiments

Considerable experiments using animals have been carried out both in the East and in the West. These have made a vast contribution to research, particularly in aspects, which could not be easily undertaken with human volunteers due to questions of ethics. Research was also carried out using healthy animals to help clarify important parameters such as optimum flux density, frequency and treatment times (Toprotsev and Taranov [9] 1982) Short duration treatments were therapeutic, while long exposure could have adverse effects in some instances. They also carried out comparative experiments with the conclusion that pulsed magnetic fields were the most effective.

Animal experiments also made significant contributions to identifying the effects of magnetic fields on biochemistry, immune responses, infectious diseases, cancer and reproductive functions. The majority of studies on reproduction showed that there were no adverse effects. Pafkova[10] (1992) found no higher incidence of mortality or malformation in chick embryos exposed to MF. However, in one case rats suffered a higher rate of mortality. The significance of this was thought to be due to a long exposure at a rate of 90 minutes daily over a 4 month period.

Despite the fact that it is generally recommended that magnetic therapy is contra-indicated in cases of cancer, animal research has been carried out on experimental tumours. Trials indicate that tumours have been caused to shrink. This effect has been seen both for pulsed therapy (Zakharyuta[11] 1987) and extremely high gauss magnets[12].

Clinical research

This covers a very wide scope, particularly with the input from Eastern Europe. It had been known from the 1940's that magnetic fields were thought to influence the cellular membrane. This lead to the concept that PEMF accelerated the re-establishment of normal potentials. (Sansaverino[13] 1980) Warnke[14] suggested that magnetism could cause hyperpolarisation of synaptic membranes, resulting in pain control. Biochemical reactions, again at the cellular level, due to magnetic fields could be the mechanism for enhanced fracture union. (Madronero[15] 1990) Increasing research has supported these ideas, and has also indicated that magnetic therapy can bring about an improvement over a wide range of conditions.

a) Peripheral Vascular Disease

Conditions investigated include oedema, ischaemia and stroke. Oedema has many causes, and many parts of the body may be affected. Pulsed magnetic therapy has been shown to reduce oedema. The re-establishment of normal potentials in the cell helps reduce oedema and is therefore of benefit in many soft tissue injuries.

A comparison of static and sinusoidal fields applied to atherosclerotic and endarteritis obliterans was carried out by Demetski and Kartashov[16]. Best results were from sinusoidal fields, up to 66% improvement was achieved which lasted up to 10 months afterwards. There was evidence of improved circulation. A study of over 3,000 patients was carried out by Detlavs[17] et al, comparing efficacy of static and pulsed fields. A total of 30 exposures, each of 10 minutes were applied. Results showed increase in number of capillaries after just a single treatemt. Hypocoagulation was also achieved. Other work included Benda and Dipoldova[18] (1986 - 1990) - effects of PMF on ischaemic disorders of limbs due to diabetes mellitus.

b) Heart disease

Improved blood flow benefits patients suffering from heart disease and from hypertension. Kirichenko[19] found some improvement in these conditions. The frequency of angina attacks were reduced by 57% when patients were given 15 minutes PMT on alternate days (Ezhova[20]). In each of these experiments the total number of treatments was 12 or below.

c) Neurological Diseases

A vast range of conditions can be covered under the heading of neurology, including migraine, epilepsy and multiple sclerosis and Parkinson's disease. Valentovna[21] (1987, 1990) used PMT to see if the latter could be improved. Significant results were achieved with 94% of patients reporting general improvement. Up to 12 treatments each of 20 minutes were given at a frequency of 25Hz. MS patients were also treated, but in this case single exposures of 10 minutes were given to the thoracic and lumbar spine and to the lower limbs. While some improvement was noted, most work in the field of MS and Parkinson's has been carried by Sandyk[22] using pico-tesla devices.

Some progress has been made in investigating the use of magnetic therapy to generate nerve growth, although this is still in its early stages. It has been found that 20 minutes daily exposure at 2Hz can stimulate up to 35% increase in neurite growth in cultures. (Sisken[23]) More recently, neurite growth in rats has been stimulated using pulsed magnetic therapy.(Walker)[24] The rats had crushed sciatic nerves, but after treatment no functional difference was apparent, however the experiment needs to be repeated on a larger scale to be of statistical significance.

d) Rheumatoid diseases and orthopaedics

Pulsed magnetic therapy also promotes the healing of fractures. It has been suggested that this is due to the PMF stimulating the small piezo-electric currents that naturally occur in the bone and encourage the attraction of bone building cells. Several factors are now known to be involved. Sahinoglu[25] (1996) reported that PMF's induce osteogenesis. Liu[26] (1996) found that PMF's had a beneficial influence on the metabolism of skeletal tissues, including cartilage. The use of PMF's conserved the homeostatic balance of cartilage in the extra-cellular medium. This research also looked at changes in the degredation and synthesis of glycosaminoglycan and collagen. It was suggested that PMF's could have a therapeutic role in the treatment of cartilage disorders in addition to their accepted use in enhancement of fracture unions.

Research into the use of magnetic therapy in fracture repair has possibly encouraged research into this field more extensively than others. Both static and pulsed have been used in trials. Pabst[27] et al found that the use of magnetic foil proved superior to other standard treatments for minor muscular injuries and secondary tendonyosis, with statistically significant results achieved in 10 days. In connection with spinal injuries, pulsed treatment reduced pain and spasm. It was also noted that PMT did not exhibit any placebo effect. (Valentova[28]) There is also considerable interest in the use of magnetic therapy to prevent or reverse osteoporosis.. Tests have shown that bone density can be increased significantly compared to controls (Haas[29] 1993) Patients were given 30 treatments of 45 minutes duration over 8 to 12 weeks, supplemented by vitamins, oestrogen and calcium.

e) Dermatology

Both static and pulsed fields have been applied to treat a range of skin conditions. Tretyakova[30] found that pulsed magnetic fields were superior to conventional ointment. Fifty patients with atopic eczema were treated at 50Hz for 10 minutes daily. By the end of the experiment all were improved, with 30 being completely symptom free. The controls treated with conventional ointments had deteriorated. Pulsed treatment has frequently given rapid results often after only a couple of treatments. A double blind trial is now underway to treat leprosy patients. (Coulton[31])

f) Surgical Implications

Building on earlier animal experiments, Nikolski[32] applied static fields to patients immediately after spinal surgery. Most patients had pain relief within a few days of the operation. The rate of healing was accelerated and there was less oedema. No complications of infection occurred, but did in the control group) and as an bonus, there was a tendency to hypocoagulation. This reduced the risk of deep vein thrombosis and avoided the need for anticoagulation therapy.

g) Cancer

Research with animals has suggested that regression can occur if treated with magnetic fields. Much of the research has been carried out using static magnets. Field strengths used were above 4,000 gauss. Philpott[33] claims that fast growing melanomas can be reversed, but that constant application over several months is required using solid state magnets of greater than 2,000 G. He suggests that as cancers are very vascular, they would have a reduction of nutrients due to the vaso-constricting effect of the field. However, clinicians still suggest that treatment is contra-indicated. Not all research into tumours has been confirmed by biopsy, and, as a safety measure, if a negative effect has been observed in even a single experiment then such treatment is considered inappropriate pending further investigation.

h) Other Areas of Research

Many other medical disciplines are, and have been, involved in research. While improvements in the condition have arisen, common features of the disease process are often present, such as oedema, inflammation and infection. Time does not allow for detailed information of each investigation. A mention of some of the areas, such as gynaecology, burns, ophthalmology, immunology and paediatrics gives an indication of the scale. A world conference is now held on an annual basis to allow for dissemination of the latest findings, both for and against.

Conclusions

Magnetism already plays a significant role in medicine with the development of MRI scanners now used as a diagnostic tool. The range and depth of research carried out worldwide justifies its consideration for use in treatment. It is not a cure all, but can be used to supplement other forms of conventional treatment, whether drug related, surgical intervention or some form of physical therapy. Correctly used it can accelerate the healing process.

Research has to be carefully evaluated. Some trials have been too small scale in scale to be of statistical significance yet merit repetition in order to confirm or repute their conclusions. While there are still some experiments carried out which need to be repeated under carefully controlled conditions, many have been repeated with a sound scientific approach. Although some results are subjective, based on patient feedback, many others use clinical tools such as x-ray reports and biopsy to confirm results. For example, Haas[34] confirmed improved bone density by scans taken pre-trial then at 3, 6 and 12 months.

Main recommendations

Clinicians have determined a number of important factors to consider, especially in relation to patient safety.

a) When selecting the type of equipment to be used to produce the magnetic field, it is important to consider the strength of the field.

b) Weak fields are therapeutic, very strong fields can cause damage.

c) Frequency is important. With PMF different frequencies have different biological effects. For example, pain control requires 200Hz base frequency.

There are two areas to consider:

Duration of each treatment session can be as little as 10 minutes. Ten to fifteen treatments in total are usually sufficient to bring about an improvement. Cases not responding after 30 sessions need to be re-evaluated. Inappropriate frequency may have been used, or the problem may not be appropriate for this type of therapy. Bone is the exception to the rule, it requires longer treatment intervals over a longer duration. Fracture healing may be not be initiated until treatment has been given for a month.

In certain conditions, careful choice should be made in selecting the area for treatment. For example, to treat thrombophlebitis it is better to expose the complete limb rather than concentrating treatment purely on the inflamed area. In some cases of ischaemia, the

corresponding spinal segment should be treated as well as local exposure. Guidance should be obtained from a qualified practitioner.

General Conclusions

Time varying magnetic fields generally have a better effect than static, especially in chronic conditions.

There is no firm evidence to support claims that the north pole of a static magnet has greater effect in therapy than a south pole.

Contra-indications. In cases of pregnancy and presence of tumours, magnetic therapy is not generally recommended, despite the trials which indicate that no adverse effects arose. (See above notes) Trials into treatment of cancer continue and it may be that certain types of cancer will be appropriate for treatment this way.

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