Electrotherapy News

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Welcome to the first edition of Electrotherapy News. This is a new online journal come newsletter that brings news with regards all things electrotherapy - news on products, reviews of papers, research news hot off the press, comments and more.

Your comments about the issues raised are welcomed and it is hoped that in future editions, readers suggestions and news from around the clinical and research communities can be posted. Send to : electronews@electrotherapyonline.co.uk

The ***Electrotherapy on the Web (www.electrotherapy.org)*** site will run as usual - it is proving to be a popular place to go and get information about electrotherapy modalities. It continues to expand, and this is one of the new spin offs - a chance to be a bit more topical.

As you may have seen from the latest site update, I am still trying to get you open access to the database of electrotherapy research publications that I have - the problem is effectively one of cost, but I have a couple of applications for funding in the pipeline, so fingers crossed.

ElectroNews also brings you details of new products and offers from the manufacturers. Whilst I don't sell anything directly, I am in close contact with many of the manufacturers and distributors and I am happy to pass the information on your way. By including a new machine or equipment in the newsletter, I am not directly endorsing it - just passing on information - though I would not put information in here that I was not happy to pass on of

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All you need is to log your name and e mail and new editions will sent to your e mail about every 6-8 weeks. By all means share your copy around - or tell your friends to register themselves. Your e mail and contact details WILL NOT be passed to anybody else - guaranteed - so there will be no mass delivery of unwanted e mails

PUBLICATION NEWS . . . . ULTRASOUND

There has been a significant number of recent publications concerned with the use of Ultrasound in connection with fracture healing. There is a whole section of the website detailing some of the key papers and a summary of the research findings. A couple of the papers from 2004 that you might find of interest are :

Fujioka, H. et al. (2004). "Ultrasound treatment of nonunion of the hook of the hamate in sports activities." Knee Surg Sports Traumatol Arthrosc 12(2): 162-4.
Two cases of nonunion of the hook of the hamate were treated with low-intensity pulsed ultrasound. The patients were baseball players and had been injured as a result of hitting repeatedly. Nonunion was detected on computed tomography (CT) and was exposed to ultrasound for 20 min a day for 4 months. In both cases pain at the hypothenar eminence disappeared, and bone union was confirmed on CT at the end of the ultrasound treatment.

Ed : Although this is a paper reporting a couple of individual cases rather than an RCT, it details the effects of ultrasound used on 2 teenage lads who played baseball and had hamate fractures that were not healed at 3.5 - 5 months post injury. Both fractures went on to full union (CT scan confirmed) and at 1 year follow up, neither patient reported pain, tenderness or limited ROM at the wrist

Busse, J. W. and M. Bhandari (2004). "Therapeutic ultrasound and fracture healing: A survey of beliefs and practices." 85(10): 1653-1656.
Objective: To explore current beliefs among senior physiotherapy (PT) students and orthopedic surgeons on the clinical utility of therapeutic ultrasound for assisting fracture healing. Design: Cross-sectional survey. Setting: University. Participants: Orthopedic surgeons, senior orthopedic surgery residents, and PT students in their final 6 months of study. Interventions: Not applicable. Main Outcome Measures: Percentage of respondents reporting specific perceptions on (1) the role of therapeutic ultrasound in fracture healing, (2) clinical use of therapeutic ultrasound for fracture healing, (3) rationale for not using therapeutic ultrasound for healing fractures, and (4) what constitutes a clinically significant difference in fracture healing time. Between-group comparisons were conducted for survey responses. Results: The response rate was 20 of 22 (90.9%) orthopedic surgeons, 5 of 5 (100%) senior orthopedic residents, and 34 of 50 (68.0%) senior PT students. The majority of senior PT students (58.8%) and orthopedic residents and surgeons (60.0%) surveyed reported the belief that therapeutic ultrasound may help in assisting fracture healing in some cases. However, the majority of respondents do not use this modality (60.0% of surgeons, 88.2% of Senior PT students), with most surgeons (32.0%) citing lack of evidence and most senior PT students (58.8%) indicating lack of availability as the predominant barrier. Thirty-two percent of surgeons felt that ultrasound was contraindicated and harmful to healing fractures, or that it was of no use, and 20.5% of PT students reported the belief that ultrasound was contraindicated and was, or may be, harmful to healing bone. Most orthopedic residents and surgeons (52.0%) reported that a reduction in fracture healing time of 4 weeks would be clinically significant versus senior PT students, the majority of whom (64.7%) indicated that a reduction of 2 weeks would be clinically significant. Conclusions: Some surgeons and PT students believed that therapeutic ultrasound is contraindicated and harmful to healing bone; however, most believed that therapeutic ultrasound may help in assisting fracture healing, in at least some cases. Current usage of this modality is rare, primarily due to the perceived lack of evidence and lack of availability. Large randomized trials are needed to define further the role of ultrasound in fracture healing.

Busse published a great paper back in 2002 (Busse, J. W., M. Bhandari, et al. (2002). "The effect of low-intensity pulsed ultrasound therapy on time to fracture healing: a meta-analysis." CMAJ

166(4): 437-41.) and this makes for an interesting follow up, especially given the growing evidence base for the use of ultrasound as an effective modality in fracture management

ULTRASOUND AND TENDON REPAIR . . . . I get numerous enquiries about the use of US in the management of tendon repair. There is some controversy out there with regards whether it is a) safe and (b) effective. The recent paper by Ng et al, although based on an animal model rather than a clinical trial (for obvious reasons) might be of interest.

Ng, C. O.,et al. (2003). "Therapeutic ultrasound improves strength of achilles tendon repair in rats." Ultrasound Med Biol 29(10): 1501-6.

The purpose of this study was to evaluate the effects of therapeutic ultrasound on structural properties and functional performance of Achilles tendon healing. Thirty Sprague-Dawley rats with surgical hemitransected Achilles tendon were studied. Ten were treated daily with 1 MHz continuous ultrasound at 1.0 W/cm2 for 4 min, 11 at 2.0 W/cm2 for 4 min and nine served as control without treatment. Achilles functional index (AFI) was recorded preoperatively and on postoperative days 3, 10 and 30. On day 30, the rats were sacrificed and Achilles tendons were tested for load-relaxation, stiffness and ultimate tensile strength (UTS). Results showed that UTS of both low-dose (p=0.023) and high-dose (p=0.002) groups was significantly greater than in controls. No significant differences in AFI (p=0.179), load-relaxation (p=0.205) and stiffness (p=0.842) were found among groups. These findings suggested that both low- and high-dose therapeutic ultrasound accelerate the healing process of ruptured tendon.

Ed : Both the US groups were treated with 1MHz continuous for 4 mins daily, 6 days a week from day 5 until day 30. The treatments were delivered under water using a stationary technique. Given that both low and high treatment doses were effective, and that there was not a statistically significant difference between the outcomes (in terms of ultimate strength), it might be appropriate to use a lower dose in the clinical environment. It would be interesting to retest, using this model but using even lower doses to see how low one could go before the beneficial effect was lost.

A second paper by Ng et al (Ng, G. et al. (2004). "Comparison of therapeutic ultrasound and exercises for augmenting tendon healing in rats." Ultrasound Med Biol **30**(11): 1539-1543) compares the outcome of two different ultrasound doses, running and swimming on Achilles tendon repair. The higher intensity US group and the running group did best, with the lower intensity and the swimming groups faring less well.

Last of the US papers for this issue is concerned with the thermal effects of the modality in muscle tissue

Leonard, J., M. Merrick, et al. (2004). "A comparison of intramuscular temperatures during 10-minute 1.0-MHz ultrasound treatments at different intensities." J. Sport Rehabil. 13(3): 244-254.

Context: *Research on therapeutic ultrasound has not focused on the duration needed to cause thermal change with various ultrasound intensities.* ***Objective****: To analyze triceps surae intramuscular temperature using 4 intensity levels after a 10- min 1-MHz continuous ultrasound treatment at a depth of 4 cm.* ***Design****: 1 x 4 repeated measures.* ***Independent variable:*** *intensity of 4 levels-0.5, 1.0, 1.5, and 2.0 W/cm(2).* ***Dependent variable:*** *peak intramuscular temperature.* ***Setting:*** *Research laboratory.* ***Participants:*** *19 volunteers with no lower leg pathologies.* ***Intervention:*** *Treatment order was balanced via Latin square and performed 24 hr apart.* ***Main Outcome Measures:*** *Peak intramuscular temperatures.* ***Results****: The only significant difference detected was that the mean temperature after the 1.0-W/cm(2) treatment (37.3 degreesC) was greater than that at 2.0-W/cm(2) intensity (36.1 degreesC). No treatment reached the desired 4 increase needed for therapeutic efficacy.* ***Conclusions****: Treatments at 1.0 W/cm(2) increased tissue temperatures more than those at 2.0 W/cm(2).*

Ed : The thermal effects of US have been debated at some length over the years. In the UK, the emphasis tends to be towards utilisation of the 'non thermal effects' whilst in the USA, thermal applications appear to be the norm. Most of the research I review on the web focuses on the non-thermal effects, so I thought that this might redress the balance a bit. Other goof thermal US papers to look at if you are interested are those by Draper and a variety of colleagues. The US in this paper was delivered at 1 MHz with varying intensity as per the abstract. A room temperature gel couplant was employed, and the treatment was stopped if pain or discomfort was reported (this happened on four occasions). It appears that most of the subjects reported discomfort by the end of the 10 minute treatment period. There is an interesting discussion with regards the difference in outcome between this study and others using a similar methodology. The failure to reach a therapeutic temperature increase of 4 degrees C is also interesting to note. The physical effects of US make it relatively inefficient as a thermal modality, though the results from this particular trial may relate to the specific machine tested.

AND FINALLY . . . . . .

For those of you that thought that all electrotherapy research was boring, sad and only for nerds . . . . Try this one . . .

Brensing, K. et al. (2003). "Can dolphins heal by ultrasound?" J Theor Biol 225(1): 99-105.

In recent years, dolphin-assisted therapy has become very popular and an increasing number of facilities offer therapy programs with dolphins worldwide. To this date, there are no studies concerning the behavior of dolphins during these therapies. As a result of speculations that the echolocation of dolphins may play an important role for the success of the therapy and the high publicity of this in the media, people pay much more for dolphin-assisted than for other animal-assisted therapy programs. Based on publications in medicine, we will show that ultrasound emitted by dolphins could have an effect on biological tissue under some circumstances; such as sufficient intensity, repeated application over several days or weeks and a certain application duration per session. We recorded 83 sessions at the "Dolphins Plus", a fenced area with ocean water in the Florida Keys. Our observations demonstrate that only one out of five observed dolphins behave significantly differently towards patients compared to other humans and that the duration of the observed close contacts did not meet the requirements for common ultrasound therapies.

Excellent . . . Why didn't I think of doing that . . . . More fun that working in a lab eh????

Seen any interesting papers?
Is there a paper that you have written and think ought to be reviewed here?
E mail and let me know
electronews@electrotherapyonline.co.uk

PUBLICATION NEWS . . . . ELECTRICAL STIMULATION

OK, four electrical stimulation papers from the somewhat MASSIVE pile on my desk. . . . .
The first 2 relate to nerve injury and the use of E Stim as part of the recovery programme. The first might seem somewhat obscure, but the findings are interesting and are worth bearing in mind, even if you don't think that you'd want to apply it in your own clinical environment. Long term muscle plasticity is certainly demonstrated here!

Kern, H., S. Salmons, et al. (2005). "Recovery of long-term denervated human muscles induced by electrical stimulation." Muscle Nerve 31(1): 98-101.
We investigated the restorative potential of intensive electrical stimulation in a patient with long-standing quadriceps denervation. Stimulation started 18 months after injury. After 26 months, the thighs were visibly less wasted. Muscle cross-sectional areas, measured by computerized tomography, increased from 36.0 cm(2) to 57.9 cm(2) (right) and from 36.1 cm(2) to 52.4 cm(2) (left). Knee torque had become sufficient to maintain standing without upper extremity support. Biopsies revealed evidence of both growth and regeneration of myofibers. The results suggest that electrical stimulation may offer a route to the future development of mobility aids in patients with lower motor neuron lesions.
Ed : The interesting thing (or one of them) about this study was that the significant changes in muscle structure were not proportionally reflected in the peak power output of the muscle when tested at the end of the (long) rehabilitation period. The authors present an interesting discussion which is well worth a read.

Marqueste, T. et al. (2004). "Neuromuscular rehabilitation by treadmill running or electrical stimulation after peripheral nerve injury and repair." J Appl Physiol 96(5): 1988-95.
Numerous studies have been devoted to the regeneration of the motor pathway toward a denervated muscle after nerve injury. However, the regeneration of sensory muscle endings after repair by self-anastomosis are little studied. In previous electrophysiological studies, our laboratory showed that the functional characteristics of tibialis anterior muscle afferents are differentially affected after injury and repair of the peroneal nerve with and without chronic electrostimulation. The present study focuses on the axonal regeneration of mechano- (fibers I and II) and metabosensitive (fibers III and IV) muscle afferents by evaluating the recovery of their response to different test agents after nerve injury and repair by self-anastomosis during 10 wk of treadmill running (LSR). Data were compared with control animals (C), animals with nerve lesion and suture (LS), and animals with lesion, suture, and chronic muscle rehabilitation by electrostimulation (LSE) with a biphasic current modulated in pulse duration and frequency, eliciting a pattern mimicking the activity delivered by the nerve to the muscle. Compared with the C group, results indicated that 1) muscle weight was smaller in LS and LSR groups, 2) the fatigue index was greater in the LS group and smaller in the LSE group, 3) metabosensibility remained altered in the LS and LSE groups, and 4) mechanosensitivity presented a large increase of the activation pattern in the LS and LSE groups. Our data indicated that chronic muscle electrostimulation partially favors the recovery of muscle properties (i.e., muscle weight and twitch response were close to the C group) and that rehabilitation by treadmill running also efficiently induced a better functional muscle afferent recovery (i.e., the discharge pattern was similar to the C group). The effectiveness of the chronic electromyostimulation and the treadmill exercise on afferent recovery is discussed with regard to parameters listed above.

Ed : Chronic NMES appears therefore to have a beneficial effect after nerve injury - especially when combined with exercise. It is interesting that in the conclusion, the authors propose that it would be of interest, in future research to evaluate the effects of different types of exercise - true, but it would also be interesting to evaluate the effects of different forms of electrical stimulation.

PUBLICATION NEWS. . ELECTRICAL STIMULATION & WOUND HEALING

As you may (or may not) be aware, the combination of tissue repair / wound healing and electrotherapy is a particular interest of mine. Amongst a growing collection of papers relating to E Stim and wound healing are the following couplet from the Journal of Rehabilitation Research and Development from last year.

Demir, H. et al. (2004). "A comparative study of the effects of electrical stimulation and laser treatment on experimental wound healing in rats." J Rehabil Res Dev 41(2): 147-54.
We investigated the effects of electrical stimulation (ES) and laser treatment on wound healing in rats. A randomized-controlled trial, conducted at the Experimental and Clinical Research Centre of Erciyes University (Kayseri, Turkey), divided 124 healthy female Swiss-Albino rats into four groups. A 6 cm linear incision was made at the dorsal skin of all rats. Group 1 was given a constant direct current of 300 microA for 30 min per day. The current was applied in negative polarity for the first 3 days and in positive polarity for the next 7 days. Group 3 received a full-contact, continuous gallium-arsenide (GaAs) laser therapy, with a wavelength of 904 nm, an energy density of 1 J/cm(2), and an average power of 6 mW for 10 min per day. The remaining two groups (Groups 2 and 4) were considered the control groups and received sham treatment. All groups were treated for 10 days. Histopathologic and biochemical evaluations were conducted on 10 rats from each group on the 4th and 10th days, and wound breaking strength was measured for biomechanical evaluation on the 25th day of the study. Both ES and laser treatment proved significantly effective in the inflammatory phase compared with control groups ($p < 0.05$); however, the ES was even more effective than laser treatment, with more significant results ($p < 0.05$). In the proliferation and maturation phases, while ES and laser treatment were both found to be significantly effective treatment methods compared with the control groups, no statistically significant difference was observed between the two treatment groups ($p > 0.05$). Although ES and laser treatment both were effective in the maturation phase, increasing wound breaking strength compared with their control groups ($p < 0.05$), there was no statistically significant difference between the two treatment groups ($p > 0.05$). We conclude that ES and laser treatment both have beneficial effects during the inflammatory, proliferation, and maturation phases of a wound. Both ES and laser treatment can be used successfully in decubitis ulcers and chronic wounds, in combination with conventional therapies such as daily care and debridement of wounds; however, ES has more beneficial effects during the inflammatory phase in some parameters than laser treatment.
Ed : There are a growing number of papers published that relate one way or another to the use of what might be broadly be referred to as 'microcurrent' therapy, even though it is not always a term that is overtly used. I plan to return to this developing field in a future issue as it appears to have significant potential, and is currently probably somewhat underused in the clinical field.

Merriman, H. L. et al. (2004). "A comparison of four electrical stimulation types on Staphylococcus aureus growth in vitro." Journal of Rehabilitation Research and Development 41(2): 139-146.
We evaluated the efficacy of common electrical stimulation (ES) types on bacterial growth in vitro using clinically relevant conditions. Four types of ES-continuous microamperage direct current (μADC), high-voltage pulsed current (HVPC), low-voltage monophasic milliamperage pulsed current (LVMmAPC), and low-voltage biphasic milliamperage pulsed current (LVBmAPC)-were each applied to a separate set of culture plates containing Staphylococcus aureus for 1 h at 37 °C on 3 consecutive days. After ES treatment, the zone of inhibition surrounding each electrode was measured. Zone of inhibition measurements showed a significant inhibitory effect for continuous

µADC and HVPC ($p < 0.05$), but not for LVMmAPC and LVBmAPC. Differences in bacterial growth inhibition were not found for polarity and time. These data suggest that for infected wounds, HVPC and continuous µADC treatments may have an initial bacterial inhibitory effect, which does not significantly change with subsequent treatments.

Ed : There have been several studies over the years that have looked at the effect of E Stim and anti-bacterial type effects. There has been debate with regards the possibility that this is simply an effect of the ions released at the electrode site, though these have largely been put to bed. This paper is interesting in that it appears to have identified a differential effect between different forms of electrical stimulation modes - including another 'microcurrent' type application

Finally, and as a precursor to a more extended review in the next issue, the emerging issue of the relationship between various forms of electrotherapy and the production / release of growth factors, known to strongly influence repair and wound healing. The following paper from the Journal of Cell Science relates to a growing interest in the role of VEGF as a very significant mediator of the angiogenic response in repair.

Zhao, M. et al. (2004). "Electrical stimulation directly induces pre-angiogenic responses in vascular endothelial cells by signaling through VEGF receptors." J Cell Sci 117(3): 397-405.

Controlling angiogenesis is crucial. Growth factors and cytokines are key regulators but a full understanding remains elusive. Endogenous electrical potential differences exist within and around the vasculature, both in relation to blood flow and in situations where active angiogenesis occurs, such as wound healing, development and tumor growth. Recent work shows that electrical stimulation induces significant angiogenesis in vivo, through enhanced vascular endothelial growth factor (VEGF) production by muscle cells. We report that applied electric fields (EFs) of small physiological magnitude directly stimulate VEGF production by endothelial cells in culture without the presence of any other cell type. EFs as low as 75-100 mV mm-1 (1.5-2.0 mV across an endothelial cell) directed the reorientation, elongation and migration of endothelial cells in culture. These pre-angiogenic responses required VEGF receptor activation and were mediated through PI3K-Akt and Rho-ROCK signaling pathways, resulting in reorganization of the actin cytoskeleton. This indicates that endogenous EFs might play a role in angiogenesis in vivo by stimulating the VEGF receptor signaling pathway, to induce key pre-angiogenic responses. In addition, it raises the feasibility of using applied EFs to initiate and guide angiogenesis through direct effects on endothelial cells.

Ed : The role of endogenous electrical activity in relation to tissue repair and recovery after injury or disease was a significant component of my own PhD work, though I was looking at gross tissue behaviour rather than a cellular level change. There seems little doubt that these normal endog-

enous currents play a significant role in stimulating various aspects of the tissue repair process and it is a reasonable extension to consider how exogenous currents (like those we would deliver with electrotherapy) could have similar effects - though these appear to be dose and treatment parameter dependent, which may be the critical issue.

Clearly, these are just a few of the papers published every year which relate to the use and further development of Electrotherapy. Those included here have only considered the use of ultrasound and some elements of electrical stimulation. I think the plan will be for each issue to follow either a couple of modalities or to run some form of theme - like fracture healing or incontinence . . . . The next issue will hopefully include some coverage of the relationship between various forms of electrotherapy and growth factors - a growing and a fascinating research area.

Additionally, I plan to update some information that I have been working on, along with others, with regards the dangers, contraindications and precautions that relate to the usual electrotherapy modalities. I get more e mails a week related to dangers and contraindications than anything else, so an update might be in order. I also plan to update the relevant sections of the web site - so keep a look out.

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