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# TESTING THE EFFECT OF DIFFERENT ELECTROTHERAPEUTIC PROCEDURES IN THE TREATMENT OF CANINE ANKYLOSING SPONDYLITIS

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*This paper presents the results of studies on the effects of suppression of chronic pain by currents with low (TENS), medium (Intf) and high (MT) frequencies, in dogs with ankylosing spondilytis. Prior to imaging diagnostics the dogs were clinically observed, trias was estimated, as well as habitus, neurological signs and degree of pain. After a 10 day treatment it was clear that all three treatments resulted in a significant decrease of pain at rest, during activity or during palpation. TENS currents have shown the highest degree of effect. All treated animals have shown improved motility after a few months of therapy. Despite the fact that all animals had an improved clinical picture none of the applied currents resulted in a complete loss of limping. Dogs treated with Intf currents displayed a decrease in muscular atrophy. Motility of the coxofemoural joint was most evident in the group treated with microwaves.*

*Key words: ankylosing spondilytis, dog, interferential currents, microwaves, TENS currents*

## INTRODUCTION

The pathology of canine vertebral osteoarthropathies is very diverse. Besides trauma, vertebral column deformities, intervertebral discus protrusion, intradiscus calcinosis, ankylosing spondylitis is common in everyday practice. This disease manifests itself by motion difficulties, pain on standing and sitting and problems with urination and defecation. Periostal ossifications of the vertebral column were noticed on various species of mammalian fossils. There is evidence that ankylosing spondylitis (AS) occurred in paleocenic primates. Rothschild and Wood (1992) investigated 1669 primate fossils from 10 prehistoric collections. They found syndesmophytes and sacroiliac erosions or fusions in 2.1% of the specimens. These lesions were somewhat scarcer in small monkeys (3.2%) compared to large apes (6.7%). However, these lesions were not registered in orangutans. A detailed account of ankylosing spondylitis lesions in an 18.5 year old rhesus monkey was given by Sokoloff. He compared these to postmortem hyperossic spondylitis in other monkey species (Sokoloff *et al.*, 1968). Identical lesions on fossil spines were found in prehistoric cats (Bjorkengren *et al.*, 1987) dogs, pigs, sheep and horses.

Factors that can lead to osteoarthritis include racial predisposition, primary disturbances of: joint soft tissue, subchondral bone, synovia, periarticular musculature or sensory nerves in the vicinity of the joint. Neuropathic arthropathies and sensory neuropathies can cause common and severe malformations on articular surfaces (Brandt, 2004). Degeneration of articular cartilage of the spine can be caused by trophic factors related to endarteritis, repeated irritation or trauma (Vaughan-Scott and Taylor, 1997). The most precise evaluation of ankylosing spondylitis was established in 1984 and is based on the New York criteria which are based on clinical and radiological tests.

*Modified New York criteria for diagnosing ankylosing spondylitis (SA)*

1. Clinical criteria:
   – Tenderness and stiffness in the lumbar region lasting longer than 3 months, alleviated by exercise, not by rest;
   – Limited mobility of the lumbar spine in frontal and sagittal planes;
   – Reduced breathing mobility for gender and age.
2. Radiological criteria:
   – II degree bilateral sacroilitis or III-IV degree unilateral.

A final diagnosis of ankylosing spondylitis can be passed if radiologic criteria are combined with at least one clinical criterion (Van Der Linden *et al.*, 1984).

Drug treatment of spine diseases is based essentially on the combination of steroids and non-steroid anti-inflammatory drugs. Such a combination cannot be sustained for prolonged periods, thus physical therapy has an important place in treating these patients (Monk *et al.*, 2006). The effect of different means of physical therapy depends on the quality and quantity of the applied energy, and on the extent to which tissues and the organism on whole can absorb the applied energies (Millis and Levine, 1997). The absorbed energy causes an active tissue reaction that leads to a sequence of local and general effects (Lambrechtsten *et al.*, 1992). Mirutova *et al*. (2006) studied the suppression of chronic pain with low frequency currents at 10 Hz and the changes of blood biochemistry in patients with osteochondrosis and osteoarthritis. Chronic non-diagnosed and untreated spondyloarthritis give paresis and paralysis of dubious prognosis. The disease has a progressive course. Several years pass before complete fusion of articular surfaces between vertebral bodies. Long term drug treatment can give unwarranted side effects, some of which can be rather sever. Physical therapy can replace or reduce the use of analgesics and steroids (Speciale and Fingeroth, 2000).

Patients with spine lesions can be treated by different electrotherapeutic methods, the most common being transcutaneous electric nerve stimulation (TENS currents) and electro stimulation by rectangular and exponential impulses

(Hayashi *et al.*, 2007; Smarick *et al.*, 2007). Besides these it is possible to use interferential currents and high frequency, Tesla currents as microwaves, or treatment by low frequency non-homogenous magnetic fields (Kahanovitz *et al.*, 1994) and other forms of electric energy with greater or smaller excitatory or tranquillizing effects.

Low frequency impulse alternating currents (TENS) are used for pain relief by stimulating nerve endings in the skin. The mode of action is based on the theory of gate control in the posterior horn of the spinal chord gelatinous mass. Besides their inhibitory influence on afferent thin myelinated A (delta) fibers and thin non-myelinated C fibers that regulate chronic and acute pain, these currents selectively stimulate afferent thick A fibers that close the pain gate. In the brain and spinal column they cause secretion of endogenous opioids, beta endorphins, enkephalins and dynorphins (neoendorphins) that have analgesic effects.

Interferential currents are low frequency modulated currents that originate in tissues by a superposition of midfrequency currents from two independent current circuits (currents varying in frequency, but of same strength). In the intersection of lines of force from two independent current circuits, a low frequency current originates in tissues and its frequency is the difference of frequencies of the two. Interferential currents are characterized by an apolar system of stimulation, i.e. they are stimulating both at the cathode and anode. Their analgesic effect is based on the stimulation of thick myelinated A fibers, control of the pain gate and release of endorphins, all of which stimulate metabolism and diffusion.

During high frequency electrotherapy, the absorbed energy of microwaves is transformed into endogenous heat. This effect is most pronounced in tissues rich in water. At a depth of 4 to 7 cm from the skin surface, microwaves cause hyperemia with blood and lymph vessel dilation resulting in an increase of local metabolism, reapsorption of waste products and edema reduction (Weinberger *et al.*, 1989). Besides this, Tonomura *et al.* (2008) proved that microwaves stimulate the creation of joint collagen matrix. High frequency currents do not thermally influence subcutaneous fat or bone, because they are poorly absorbed by them, but have a considerable analgesic, anti-inflammatory and anti-edematous effect on chronic arthritis (Weinberger *et al.*, 1990). Microwave frequencies of 2450 MHz and wavelengths of 12.2 cm are used for treatment, the dosage is according to the sensation of heat they produce.

Besides these electrotherapy procedures whose importance in animals with ankylosing spondylitis is particularly stressed (Dejardin *et al.*, 2001), good results are obtained through kinesitherapy (Marcellin-Little *et al.*, 2007), massotherapy (Saunders *et al.*, 2005) and thermotherapy.

## MATERIALS AND METHODS

*Electrotherapy* was performed on 24 dogs (13 males and 11 females) with clinically and radiologically confirmed ankylosing spondylitis. The dogs were of larger breeds (German shepherds, Doberman pinchers, Rottweilers and Great Danes), weighing 35 to 60 kg, and aged 5 to 15 years. The dogs were first observed with an evaluation of habitus, after which a neurological exam was performed evaluating posture, movement, hyperesthesia and reflex analysis (cranial, spinal, cutaneous and anal). A questionnaire was filed by the vet and by the owner concerning vocalization, abnormal behavior, limping, muscle atrophy, stance and skin sensitivity. Most of the valid parameters such as posture, degree of muscle atrophy and mobility of the hip joint were valued from 1 to 4. To determine the pain level objective parameters were used, such as heart rate, breathing rate, as well as subjective data determined by a pain questionnaire. Pain at rest and during activity, as well as on palpation of the spine was valued using a visual analogue scale VAS graded from 0 (no pain) to 10 (maximal pain).

After clinical and neurological examination we performed X rays of the vertebral column to determine the extent of ankylosing spondylitis. We also visualized the pelvis to exclude deformations and proliferations on the hip joints that could mask pain when analyzing hip mobility. X rays were taken in the latero-lateral (LL) and ventro-dorsal (VD) projections. We used a SELENOS 4 roentgen machine with 55 to 60 KV voltage, 20 to 25 mA current and 0.003 to 0.005 second exposure. In all cases, the film to focus distance was 70 cm. As all dogs weighed over 30 kg we used a Potter Buky shutter and Kodak MXG 100 NIF films, 24 by 30 cm and 30 by 40 cm.

Before the experiment the animals were divided into three groups of 8 animals each. Animals in group 1 were treated with *transcutaneous electrical nerve stimulation* (TENS). Dogs from group 2 were treated with medium frequency *interferential currents*. Dogs from group 3 received high frequency (Tesla) currents in the form of *microwaves*. The evaluation of the effects in each group was done on a "one group pre-test, post-test" review.

TENS currents were applied by an INTELDIN PLUS apparatus. The current was emitted as alternating, low frequency symmetrical impulses at 85 Hz. The width of the impulse was 0.4 ms, with a gradual increase of 0.1 ms every other day to a maximally permitted value of 1 ms. Muscle contraction time was 12 seconds, and relaxation time 24 seconds. The applied current was 7 mA in strength and it was applied every day for 15 minutes during 10 days. The application method was stable (fixed electrodes).

The same apparatus was used for *interferential* currents, using a four-pole electrode technique with a four lead cable. One lead pair was used to emit a constant frequency current of 4000 Hz, while the other lead pair was used to emit a variable frequency current of 3850 to 4000 Hz. The electrodes were fixed paravertebrally so that the current lines of the two circuits cross in the region of the pathological lesion. After that there was a dynamic change of current intensity by 30 mA $\pm$ 10% and a slow change of interferential frequency of 50 to 150 Hz and back, all of which gave an analgesic effect. Interferential currents were applied 15 minutes for 10 days.

As a *microwave* source we used a magnetron BOLOGNA oscillator. The antenna was a semi cylindrical radiator adapted for internal organ and joint irradiation. The radiator was placed 5 to 10 cm from the body surface. The magnetron had an output power of 40 W and emitted microwaves of 2450 MHz $\pm$

50 Hz frequency and a wavelength of 12.2 cm. The microwave therapy was administered every day for 15 minutes for 10 days.

After 10 days of electrotherapeutical procedures, the process of pain evaluation was repeated to determine the effects of treatment. During the treatment the patients were kept in domestic conditions, and the owners were instructed to reduce daily activities.

## RESULTS AND DISCUSSION

Twenty four affected animals (13 males and 11 females), 5 to 15 years old, were divided into 3 groups of 8 animals each. Animals from each group received different electrotherapeutic treatment. At the beginning of treatment there were no significant differences in age, gender, or severity of the spinal disease between the groups. The mean age in the first group was 9.37 ± 3.16, 9.62 ± 1.41 in the second group and 9.75 ± 3.01 years in the third group. The mean duration of pain in the first group was 4.12 ± 0.83 months, 3.75 ± 0.71 in the second group and 3.56 ± 0.73 in the third group. A single-factor variance analysis showed no significant difference for the mean ages ($F=0.042$, $p>0.05$) or pain duration ($F=1.140$, $p>0.05$) between the groups.

Figure 1. Spinal column X ray of a dog affected by ankylosing spondylitis

Table 1 shows the descriptive statistic parameter indices for the evaluation of chronic pain for all 3 groups before treatment. Single factorial variance analysis showed that there was no significant difference for the mean pain level at rest ($F=0.131$, $p>0.05$), pain during activity ($F=0.091$; $p>0.05$), gait ($F=0.162$; $p>0.05$), tenderness to touch ($F=0.614$; $p>0.05$), lameness ($F=0.007$; $p>0.05$), muscle atrophy ($F=0.532$; $p>0.05$) and joint flexibility ($F=0.118$, $p>0.05$).

Table 1. Comparison of chronic pain parameters before treatment between groups

| | Group 1 (TENS) | Group 2 (IFC) | Group 3 (MW) | F | p |
|---|---|---|---|---|---|
| Observed variables | X ± SD | X ± SD | X ± SD | | |
| Pain at rest (VAS) | 3.75±1.04 | 3.55±0.82 | 3.51±1.10 | 0.131 | >0.05 |
| Pain during activity (VAS) | 7.47±0.93 | 7.26±1.17 | 7.29±1.15 | 0.091 | >0.05 |
| Gait | 1.57±0.57 | 1.64±0.70 | 1.77±0.86 | 0.162 | >0.05 |
| Tenderness to touch (VAS) | 1.96±0.62 | 2.35±0.88 | 2.05±0.67 | 0.614 | >0.05 |
| Lameness | 2.02±0.93 | 1.99±0.86 | 1.97±0.79 | 0.007 | >0.05 |
| Muscle atrophy | 1.72±0.42 | 1.87±0.30 | 1.70±0.38 | 0.532 | >0.05 |
| Hip sensitivity on movement | 2.42±0.51 | 2.35±0.81 | 2.51±0.66 | 0.118 | >0.05 |

Student's t test for paired samples was used to compare chronic pain parameters before and after treatment for every examined group of dogs with ankylosing spondylitis. In the group treated with TENS there was a statistically highly significant pain reduction at rest ($t=4.665$; $p<0.01$), during activity ($t=6.434$, $p<0.01$) and touch tenderness ($t=4.099$, $p<0.01$), and coxofemoral joint mobility ($t=7.445$, $p<0.01$). In the group treated with interferential currents there was a statistically highly significant decrease of pain during activity ($t=11.513$; $p<0.01$), a reduction of tenderness to touch ($t=5.014$, $p<0.01$) and a reduction of muscle atrophy ($t=7.155$; $p<0.01$), and a highly significant increase in mobility at the coxofemoral joint ($t=3.550$, $p<0.01$). IFC reduced pain at rest at a significant level ($t=2.520$; $p<0.05$).

In the group of dogs with ankylosing spondylitis treated with microwaves there was a statistically highly significant reduction of pain in activity ($t=5.935$; $p<0.01$), tenderness to touch ($t=4.912$; $p<0.01$), and joint mobility ($t=5.584$; $p<0.01$), as well as a significant reduction of rest pain ($t=2.472$; $p<0.05$) (results not shown in table).

Table 2 shows observed parameters in the three groups of dogs after a ten day course of physical therapy. Using a single factor analysis of variance there was a significant difference in pain level between observed groups ($F=3.518$; $p<0.05$) such that the lowest level of rest pain was in the group treated with TENS (2.12±0.81). Repeated comparisons by the method of the least significant difference, we obtained a statistically significant difference between groups treated by TENS and IFC ($p<0.05$) and groups treated by TENS and MW ($p<0.05$); between groups treated with IFC and MW there was no significant difference of rest pain ($p>0.05$).

Single factor analysis of variance (ANOVA), shows a statistically significant difference in pain during activity between the observed groups ($F= 4.140$, $p<0.05$). The least pain was in a group of dogs treated with TENS (4.65±0.89). Repeated comparisons by the method of the least significant difference obtained a statistically significant difference between groups treated by TENS and MW

($p<0.05$) for pain during activity. For dogs treated by TENS and IFC there was no statistically significant difference ($p>0.05$). Also, there was no significant difference between dogs treated with IFC and MW ($p>0.05$). As for muscular atrophy, single factor analysis of variance showed a statistically significant difference after physical therapy for the observed groups ($F=4.692$, $p<0.05$). Repeated comparisons by the method of the least significant difference obtained a statistically significant difference for muscle atrophy between groups treated with TENS and IFC ($p<0.05$), as well as for groups treated with IFC and MW ($p<0.05$), while there was no significant difference between groups treated with TENS and MW ($p>0.05$). By the same statistical method (single factor ANOVA) there was a statistically significant difference in the mean hip mobility for the observed groups ($F=4.692$; $p<0.05$). Repeated comparisons by the method of the least significant difference, resulted in a statistically significant difference between groups treated by TENS and MW for hip mobility ($p<0.05$), as well as between groups treated with IFC and MW ($p<0.05$). Between the group treated with TENS and the one treated with IFC there was no statistically significant difference ($p>0.05$). It should be said that there was no significant difference before and after a 10 day treatment, when compared by single factor analysis of variance, for the following parameters: tenderness to touch ($F=1.033$, $p>0.05$), gait ($F=0.121$, $p>0.05$) and lameness ($F=0.049$; $p>0.05$).

Table 2. Comparison of pain estimate parameters after treatment

| | Group 1 (TENS) | Group 2 (IFc) | Group 3 (Mw) | F | p |
|---|---|---|---|---|---|
| Observed variables | x±SD | x±SD | x±SD | | |
| Pain at rest (VAS) | 2.12±0.81 | 2.94±0.69 | 2.95±0.62 | 3.518 | <0.05 |
| Pain during activity (VAS) | 4.65±0.89 | 5.72±0.86 | 5.39±0.47 | 4.140 | <0.05 |
| Gait | 1.37±0.50 | 1.49±0.62 | 1.39±0.35 | 0.121 | >0.05 |
| Touch tenderness (VAS) | 1.36±0.59 | 1.76±0.75 | 1.39±0.50 | 1.033 | >0.05 |
| Lameness | 1.76±0.91 | 1.84±0.75 | 1.89±0.74 | 0.049 | >0.05 |
| Muscle atrophy | 1.61±0.42 | 1.15±0.09 | 1.62±0.43 | 4.692 | <0.05 |
| Hip sensitivity on movement | 1.84±0.49 | 1.90±0.56 | 1.29±0.15 | 4.692 | <0.05 |

Before treatment we did not have a statistically significant difference between mean age, pain duration, and all of the parameters for chronic pain evaluatin, so that we could compare the groups in time. All three treatments gave a highly significant pain reduction during activity and touch tenderness. TENS currents give a highly significant reduction of pain at rest, while in group 2 and 3 pain reduction is at a significant level. This is confirmed by the ANOVA results for rest and activity. After treatment pain level at rest is statistically significantly lower in group 1 (2.12±0.81) compared to group 2 (2.94±0.69) and group 3 (2.95±0.62). There is no significant difference between groups 2 and 3 during rest. Pain during activity is significantly lower in the first group (4.65±0.89) compared to the second group (5.72±0.86). Although all three treatments reduce pain, TENS is the therapy that most reduces pain during rest and activity. These results can be compared to those obtained during treatment of partially paretic dogs by simultaneous electroacupuncture and herbal remedies (Hayashi *et al.*, 2007b). After ten treatments these dogs showed greater motor activity. Six months later, with determined exercises, these dogs were free from symptoms. The better effect of TENS currents in pain inhibition, compared to IFC and MW is explained by the theory of pain entry and its block because of competition between conducting nerve fibers and those closing the pain gate in the gelatinous substance on the posterior horns of the spinal cord. The current frequency used for TENS in dogs with ankylosing spondylitis was 85 Hz, causing a potent analgesic effect, current strength was below the threshold of motor stimulation, which gave pleasant sensations below the electrodes instead of muscle spasms.

Although every group showed improvement, none of the therapies gave a statistically significant improvement in gait or lameness. Only in the group treated with IFC was there a significant reduction of muscle atrophy. After treatment muscle atrophy was statistically significantly lower in group 2 (1.15±0.09) compared to group 1 (1.61±0.42) and group 3 (1.62±0.43). This effect is explained by the fact that IFC have a greater frequency compared to TENS currents, thus reducing their stimulating effect, as well as by the capacitive skin resistence, so that they can be used at much higher intensities compared to low freqeuncy currents. With low frequency currents there is dispersion of current lines between the electrodes in tissues, with interferential currents, by adequate electrode positioning along the spinal column, a sufficient density of current to obtain a therapeutic effect is achieved. Rhythmic current frequency of 10 to 150 Hz has an attenuation property that diminishes with the exitatory effect. The interferential frequency modulated between 50 Hz and 150 Hz, as well as dynamic change of current intensity, had a clear spasmolytic and analgesic effect. Muscle atrophy reduction in treated dogs was achieved at lower frequencies because of active hyperemia of the skin, deeper tissues and muscles, as well as increased motor nerve excitability without a plateau effect i.e. without causing permanent (reversible) tetanic contractions.

Hip mobility was significantly increased in every group, but the best result was in the group treated with microwaves (MW). This is in compliance with the results obtained by Bakaliuk *et al.* (1998) who analyzed the effect of microwaves and concluded that they intensely suppress pain and increase joint mobility in osteoarthritis. Besides this, they have a stimulating effect on non specific immunity, lipid peroxydation and the activation of the antioxidative defense system. After microwave treatment there was a significant improvement in joint mobility comparing the third (1.29±0.15) with the first (1.84±0.49) and second (1.90±0.56) groups. This positive effect of microwaves on the skeletal system was used in the treatment of juvenile rheumatoid arthritis, either alone or combined with radon or hydrogensulphate baths (Shliapak *et al.*, 1996). The combination of decimetric waves and naphtalan with tar removed proved its benefit in patients suffering from vertebral or scapulohumeral osteoarthritis on their segmental and peripheral neuromotoric system (Musaev *et al.*, 1994), as well as on cerebral hemodynamics (Musaev and Guseinova, 1993). This explains the better hip mobility and reduced spinal pain in dogs suffering from ankylosing spondylitis treated with microwaves. Permitting insufficient precision in subjective VAS interpretation, the results of our investigation match those on the influence of nonhomogenous magnetic fields on lateral epicondyli (Uzunca *et al.*, 2007) that showed higher therapeutic effects of high frequency currents on degenerative processes of the vertebral column than those obtained with steroids, especially if used for prolonged periods.

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## ISPITIVANJE EFEKATA RAZLIČITIH ELEKTROTERAPIJSKIH PROCEDURA U TRETMANU ANKILOZIRAJUĆEG SPONDILITISA KOD PASA

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SADRŽAJ

U radu su prikazana ispitivanja supresije hroničnog bola pod uticajem struja niske (TENS), srednje (Intf) i visoke (MT) frekvence, kod pasa sa ankilozirajućim spondilitisom. Psi su pre rendgenskog snimanja opservirani, urađena im je procena trijasa, habitusa, a zatim neurološki pregled i određivanje stepena bola. Nakon desetodnevnog tretmana, uočeno je da su sva tri postupka dovela do visoko značajnog smanjenja bola u toku mirovanja ili aktivnosti i pri palpaciji, pri čemu su se isticale TENS struje u odnosu na Intf struje i mikrotalase. Kod tretiranih jedinki je zapažena izraženija motorna aktivnost, a nekoliko meseci od početka

lečenja, uz određene kineziterapijske vežbe, psi su bili sa bitno redukovanim simptomima oboljenja. Iako je u svakoj grupi ispitivanih jedinki došlo do poboljšanja stanja, ni jedan terapijski postupak nije doveo do potpunog gubitka hromosti. Jedino je u grupi pacijenata tretiranih sa Intf strujama, došlo do značajnog smanjenja stepena mišićne atrofije, a pokretljivost koksofemoralnih zglobova je bila najizraženija kod pacijenata tretiranih mikrotalasima.