J. Vet. Sci. (2003), 4(1), 97-101

JOURNAL OF
Veterinary
Science

Effects of Corticosteroid and Electroacupuncture on Experimental Spinal Cord Injury in Dogs

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Received December 16, 2002 / Accepted February 2, 2003

Abstract

The aim of this study is to investigate the effects of electroacupuncture, corticosteroid, and combination of two treatments on ambulatory paresis due to spinal cord injury in dogs by comparing therapeutic effects of electroacupuncture and corticosteroid. Spinal cord injury was induced in twenty healthy dogs (2.5~7 kg and 2~4 years) by foreign body insertion which compressed about 25% of spinal cord. There was no conscious proprioception, no extensor postural thrust, and ambulatory. Dogs were divided into four groups according to the treatment; corticosteroid (group A), electroacupuncture (group B), corticosteroid and electroacupuncture (group AB), and control (group C). Neurological examination was performed everyday to evaluate the spinal cord dysfunction until motor functions were returned to normal. Somatosensory evoked potentials (SEPs) were measured for objective and accurate evaluations. The latency in measured potentials was converted into the velocity for the evaluation of spinal cord dysfunctions. Pain perceptions were normal from pre-operation to 5 weeks after operation. Recovery days of conscious proprioception in groups A, B, AB, and C were 21.2±8.5 days, 19.8±4.3 days, 8.2±2.6 days, and 46.6±3.7 days, respectively. Recovery days of extensor postural thrust in group A, group B, group AB, and group C were 12.8±6.8 days, 13.8±4.8 days, 5.4±1.8 days, and 38.2±4.2 days, respectively. There were no significant differences between group A and group B. However, recovery days of group AB was significantly shorter than that of other groups and that of group C was significantly delayed ($p<0.05$). Conduction velocities of each group were significantly decreased after induction of spinal cord injury on SEPs ($p<0.05$) and they showed a tendency to return to normal when motor functions were recovered. According to these results, it was considered that the combination of corticosteroid and electroacupuncture was the most therapeutically effective for ambulatory paresis due to spinal cord injury in dogs.

Key words: spinal cord injury, electroacupuncture, corticosteroid, dog

Introduction

Intervertebral disc disease (IVDD) in dogs is a common clinical problem encountered in small animal practice. There are various clinical signs ranging from mild back pain to paralysis with loss of deep pain perception. Several methods of managing dogs with IVDD have been reported. Conservative therapy consists of cage confinement with medications, physiotherapy, swimming, ultrasound, massage, eventual antibiotics, laxative diet, and bladder emptying [10, 12]. Another conservative therapy, as an alternative medicine, acupuncture is useful in dogs with paresis [15]. Decompressive surgery includes fenestration, dorsal laminectomy, hemilaminectomy and minihemilaminectomy or pediculectomy [20].

The proper choice of treatment for intervertebral disc disease remains controversial although there is general agreement that several forms of decompressive surgery are most effective for dogs with severe neurological dysfunction [20]. The approach to an individual case will be influenced by the stage of the disease [7, 8, 23]. The duration of clinical signs and economic factors will also influence the choice of treatment methods [20].

Recovery rate of medications for dogs with ambulatory paresis is about 90% and recurrence rate is about 28% [9]. But decompressive surgery is the most effective in dogs with paraplegia [4, 6]. Recovery rate of medications for dogs with mild paralysis is about 50 ~ 80%, which is significantly lower than that of paresis [7]. Comparisons or evaluations

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This study was supported by Research Institute for Veterinary Science of Seoul National University.

on various decompressive surgeries and medications in dogs with intervertebral disc disease have been reported [15, 16, 20] but there are few reports on the effects of the combination of medications and electroacupuncture.

The purpose of this study is to investigate the effects of electroacupuncture, corticosteroid, and combination of two treatments on paresis due to spinal cord compression in dogs.

Materials and Methods

Experimental Animals

Neurologically intact twenty dogs (2.5 ~ 7.0 kg and 2 ~ 4 years) were divided into four groups regardless of their sex, body weight and age. Four groups were corticosteroid (Group A, n = 5), electroacupuncture (Group B, n = 5), corticosteroid with electroacupuncture (Group AB, n = 5), and control (Group C, n = 5).

Induction of Spinal Cord Compression

1. Anesthesia

Dogs were premedicated with acepromazine maleate (0.01 *mg/kg*, IV, Sedaject®, Samwoo, Korea). Ampicillin (20 *mg/kg*, IM, Penbrex®, Samyang Co., Korea) and enrofloxacin (5 *mg/kg*, SC, Baytril®, Bayer Korea Co., Korea) were administered. Anesthesia was induced with thiopental sodium (15 *mg/kg*, IV, Penthotal sodium®, Joongwei, Korea). Dogs were intubated, and the surgical plane of anesthesia was maintained using isoflurane (1.5 MAC, Aerane®, Ilsung Co., Korea). Lactate Ringer's solution with 5% dextrose (10 *ml/kg/h*, IV drip, Deahan Hartmandex®, Deahan Pharm. Ltd. Co., Korea) was administered during the surgical procedure.

2. Induction of spinal cord compression

The skin incision was made at the dorsal midline from the 2nd to 5th lumbar vertebra and a periosteal elevator was used to elevate left epaxial muscles from their attachments on the lateral aspect of spinous processes, lamina, articular facet and pedicle. Rongeur or pneumatic bur was used to enter the spinal canal and make the window of 7×3 ~ 15×5 *mm* on the left lamina according to the size of spinal canal, cautiously not to contuse the cord. Epidural fat around the dura mater was removed by suction. Spinal canal size was examined with blunt microdissector. According to the size of spinal canal, 15×8×3 ~ 8×5×2 *mm* size autogenous bone fragment was inserted through the window to compress spinal cord about 25%. Autogenous bone fragment was made from a portion of L3 spinous process. Subcutaneous fat graft was placed over laminectomy site. Epaxial muscles, subcutaneous and skin were closed routinely. After recovery from anesthesia, proprioceptive deficit and loss of voluntary movement were confirmed.

Treatment

1. Medications

In groups A and AB, fourty-eight hours after induction of spinal cord compression, methyl prednisolone sodium succinate (MPSS) (30 *mg/kg*, Bando methylprednisolone®, Bando Pharm. Co. Ltd., Korea) was administrated intravenously 6 times, q6h, then prednisolone acetate (PDS) (2 *mg/kg*, Corus prednisolone®, Corus Pharm. Co. Ltd., Korea) was given orally, bid with cimetidine (10 *mg/kg*, Cimetidine®, Sungjin Pharm. Co., Korea), misoprostol (5 *μg/kg*, Alsoben®, Unimed Co., Korea), and vit B1 (1*mg/kg*, Vitamedin®, Hanil Pharm. Co., Korea). The dosage of PDS was tapered according to clinical signs and complications. Cage confinement was applied concurrently.

2. Electroacupuncture

In groups B and AB, 48 hours after induction of spinal cord compression, electroacupuncture treatment was applied every other day at GV-4 (*Ming Men*), GV-3 (*Yao Yang Guan*), BL-23 (*Shen Shu*), and BL-24 (*Qi Hai Shu*) as local points, and GB-30 (*Huan Tiao*), GB-34 (*Yang Ling Quan*), ST-36 (*Zu San Li*), ST-40 (*Feng Long*), ST-41 (*Jie Xi*) as distal points. Out of them, at GV-4 (*Ming Men*) and ST-36 (*Zu San Li*) electroacupuncture was applied and at other acupoints traditional acupuncture was used. Electrical stimulations with 2 *V*, 25 *Hz* were done for 20 *min* by using of electrical stimulator (Pulse stimulator AM3000, Tokyo Electronic Co., Japan). Cage confinement was applied concurrently.

Evaluation

1. Neurological examination

After induction of paresis, all dogs were examined everyday on motor and sensory functions by postural reaction, superficial pain and deep pain. These neurological examinations were continued until the dogs responded normally.

2. Somatosensory Evoked Potentials (SEPs)

SEPs were measured for prediction of sensory functions. According to Poncelets method [18], SEPs were represented as spinal conduction velocity. Stimulation and measurement were performed with a 'Neuropack 2, MEM-7102' (Nihon Kohden, Japan) and subdermal 'Platinum needle electrodes' (E2, Grass, U.S.A.) were applied on the two channels. The channel 1 was located on the subdermal region between the 5th and 6th lumbar vertebra and the channel 2 was positioned between the 11th and 12th thoracic vertebra.

3. Radiology

Before surgery, plain radiograph was performed to know the size of spinal canal. According to the radiograph, the size of bone fragment to insert was determined. After surgery, myelogram was carried out to confirm that the spinal cord was compressed by inserted bone fragment.

Statistical Analysis

One-way ANOVA was performed to investigate differ-

ences among groups in recovery days of conscious proprioception and extensor postural thrust by SPSS (SPSS for windows Release 8.0 Standard Version, SPSS Ins., USA). Two-tailed Student's *t*-test was used to compare conduction velocities of pre-operation, post-operation and when motor functions were returned to normal. For statistical interpretation, significance level was set at $p<0.05$.

Results

Mean Recovery Days of Conscious Proprioception

In group A, mean recovery period of conscious proprioception was 21.2 ± 8.5 days. In group B, 19.8 ± 4.3 days, in group AB, 8.2 ± 2.6 days, and in group C, 46.6 ± 3.7 days (Table 1). Mean recovery period of conscious proprioception was significantly decreased in group AB ($p<0.05$). However, there was no significant difference between group A and group B.

Table 1. Recovery days of conscious proprioception and extensor postural thrust in each group

Group	Recovery days*	
	Conscious proprioception	Extensor postural thrust
A	21.2±8.5a	12.8±6.8a
B	19.8±4.3a	13.8±4.8a
AB	8.2±2.6b	5.4±1.8b
C	46.6±3.7c	38.2±4.2c

*Data are expressed as mean ± SD. aNo significant difference between groups. bSignificantly shorter than other groups ($p<0.05$). cSignificantly longer than other groups ($p<0.05$). group A, corticosteroid; group B, acupuncture; group AB, corticosteroid + acupuncture; group C, control.

Mean Recovery Days of Extensor Postural Thrust

In group A, mean recovery period of extensor postural thrust was 12.8 ± 6.8 days, in group B, 13.8 ± 4.8 days, in group AB, 5.4 ± 1.8 days, and in group C, 38.2 ± 4.2 days (Table 1). In group AB, mean recovery days of extensor postural thrust was significantly shorter than those of other groups (P£½0.05). Group A and group B had no significant difference in recovery days.

Somatosensory Evoked Potentials (SEPs)

After induction of spinal cord injury, conduction velocities of each group (Table 2) were significantly decreased compared with pre-operative value on SEPs ($p<0.05$). However, the conduction velocity showed a tendency to return to normal when motor functions were recovered on neurological examination.

Radiology

After surgery, myelography was taken. On myelograms, autogenous bone fragments compressing the spinal cord about 25%, which were confirmed on the image of radiopaque extradural mass between L3 and L4.

Discussion

The management of intervertebral disc disease is based on assessment of the degree of neurological dysfunction and localization of the lesion. It is now generally accepted that decompressive surgery is superior to either conservative management or fenestration, especially for those dogs that have paresis [20]. However, conservative therapy was effective as much as decompressive surgery in dogs with ambulatory paresis [8]. In this experiment, dogs were induced to the level of paresis to examine therapeutic effects of corticosteroid and electroacupuncture.

In 1983, Hoerlein evaluated dexamethasone use in cats with spinal cord injury and found dexamethasone not to be more effective than a placebo in improving neurological outcome [10]. Increasing the dose of dexamethasone to less than half of the reported equipotent high-dose protocol of MPSS (30 mg/kg) had resulted in gastrointestinal complications in dogs and cats [5, 9, 22].

The negative effects of corticosteroid treatment in neurological trauma had been described. It was suggested that corticosteroids not be used more than 24 hours after onset of herniation or more than once; their use might cause additional complications and a slower cure rate [3, 17]. Based on previous study, MPSS was selected first, and then administered PDS with cimetidine, misoprostol to minimize complication of corticosteroids.

The mechanism of acupuncture treatment needs more studies and is not yet understood. However, acupuncture

Table 2. Changes of conduction velocities between channel 1 to channel 2 in each group

Group	Conduction velocities (*m/sec*)*		
	Pre-operation	Post0operation	After recovery
A	56.77±8.81	49.73±7.36a	54.17±7.13
B	60.13±1.43	46.31±8.74a	53.22±9.44
AB	61.88±5.72	39.34±7.97a	56.99±6.34
C	70.92±4.13	52.59±6.20a	67.74±5.50

* Data are expressed as mean ± SD. aSignificantly different from pre-operation in each group ($p<0.05$).

was known to be a potent analgesic and thus it might abolish back pain. Acupuncture could activate axonal regrowth and thus regeneration of destroyed axons in the spinal cord. The faster this regrowth took place, the more axons might gain access to their original distal axonal sheathes because there was less scar tissue at the lesion. Acupuncture was a potent antiinflammatory treatment, because it might decrease local spinal inflammation, edema, vasodilation or constriction and histamine or kinin release. This would decrease scar tissue formation, cord compression or hypoxemia and pain [13].

In this study, acupoints could be divided into local and distal points. Local points were segmental urinary bladder points. Local points on the governing vessel meridian in these segments were also used. The logic of using local points was that they might have segmental effects at the site of lesion. The segmental effects were that A-beta fibers stimulated, rapidly carrying nonpainful sensory information to the substantia gelatinosa, would synapse on inhibitory interneurons that would close the "gate" to ascending pain transmission before pain impulses arrived from slowly conducting C fibers. This would prevent pain impulses from reaching higher brain centers for conscious perception [21]. Based on this principle, GV-3, GV-4, BL-23 and BL-24, close to L3 and L4 vertebra, were used as local points.

Distal points used in this study were on urinary bladder (BL), gall bladder (GB) and stomach (ST) meridians. The logic of distant points used was presumed that they stimulate nerve fibers that have an afferent input on higher centers and on the injured spinal segment. These impulses might combat inflammation and pain and activate regeneration. Acupuncture with only four needles was proved to be as effective as a slightly more extensive treatment [15]. In this study, the choice of distal points which were GB-30, GB-34, ST-36, ST-40, and ST-41 was based on a Rogers' computerized best point choice listing [13].

Stimulation methods can be divided into five categories; plain puncturing, electrostimulation of needles, laser therapy, injections at acupoints, and moxibustion [1]. Electrostimulation is used more frequently in the United States than in Europe and China [13]. The electrostimulation is applied with a wide variety of machines, a wide variety of waveforms, wave patterns and intervals, different frequencies and amplitudes. The amplitude is augmented until muscle twitching and pain is observed. In one report, electrostimulation deteriorated the condition of the patient and no better results have been reported by using electrostimulation than by plain acupuncture [14]. However, it was currently widely used in many human and veterinary acupuncture practices to treat pain and physical ailments and to induce analgesia for surgical procedures. Several advantages of electroacupuncture than traditional acupuncture were savings in time, the amount and quality of stimulation can be more accurately, uniformly, and objectively regulated and measured, and the electroacupuncture produce a higher and more continuous level of stimulation than can be provided manually [1].

In general, weak stimulation with low current and low frequency applied to an acupuncture point will tonify that point which procedure is indicated for chronic pain problems. To accomplish sedation or analgesic, high frequency, greater than 15 *Hz* (usually 25 ~ 150 *Hz*), and higher amplitude of current are used. This technique is primarily used for acute pain problems [1].

The recovery days of the dog which had negative responses on proprioception and hoping were 90% within a three-week period with electroacupuncture [9]. This was almost accorded with the result of group A in the present study.

The availability of objective and accurate methods for spinal cord function assessment could be of great help [19]. In this experiment, SEPs were measured for more objective and accurate evaluation of spinal cord dysfunctions. Several investigators have suggested that ambulation after spinal injury can be predicted by SEPs [11]. Spinal trauma may cause the reduction of conduction velocity or amplitude in spinal cord. Conduction velocities were more often affected, but were not always reduced in dogs with paralysis. Conduction velocity might have been more affected by compression, and amplitude more affected by hypoxia. However, additional studies were needed to confirm these hypotheses [2]. In this study, conduction velocities in each group after induction of spinal cord compression were significantly decreased compared to those of pre-operation.

In the present study, it was suggested that the combination of corticosteroid with electroacupuncture was significantly more effective than corticosteroid or electroacupuncture alone. It was thought to be due to a synergistic action of analgesic, antiinflammatory, antiedemic effect of corticosteroid and acupuncture.

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