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Effect of the Combination of Electroacupuncture and Surgical Decompression on Experimental Spinal Cord Injury in Dogs

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Abstract : This study was performed to evaluate the effects of the combination of electroacupuncture (EA) and surgical decompression on paraplegia due to spinal compression in dogs. Ten clinically healthy dogs were assigned into two groups (group A and group B). The one is for the combination of EA and surgical decompression, and the other is for surgical decompression alone. After decompression, neurological function was evaluated daily with modified Tarlov grading system. SEPs were measured as objective evaluation of normal spinal cord function before spinal compression and after neurological recovery. The period of rehabilitation in group A was significantly shorter than that in group B ($p<0.05$). Conduction velocity of SEPs showed a tendency to return to normal when the dogs got full recovery. According to these results, it was considered that the EA with surgical decompression was more effective than surgical decompression alone for paraplegia resulting from spinal cord injury in dog.

Key words **:** spinal cord injury, surgical decompression, electroacupuncture, dogs.

Introduction

Dogs with intervertebral disc disease (IVDD) may have mild back pain including paraplegia with loss of deep pain perception. Treatment guidelines primarily depend on the basis of the severity and duration of clinical signs[21]. Dogs that have ambulatory paresis may be treated conservatively, with or without operation. Decompressive surgery should be considered in dogs which were suffering from paraplegia with or without deep pain percection[1,22]. These surgical treatments include fenestration, dorsal laminectomy, hemilaminectomy and minihemilaminectomy or pediculectomy[19]. In general, the majority of dogs after decompressive surgery following paraplegia need supportive care and rehabilitation[13,15]. This postoperative care includes cage rest, urinary bladder expression, wound management, and physical therapy such as passive muscle exercises, hydrotherapy, and electro-therapy[9,18]. Acupucture and transcutaneous electric nerve stimulation (TENS) have been used in many clinical settings which include thoracolumbar disc disease and postoperative rehabilitation in human[23,24]. There are several case reports of successful treatments with acupuncture in dogs with IVDD[10,13,17]. However, there are few studies about acupuncture after spinal decompression surgery in small animal practice. This study was performed to evaluate the effect of the combination of electroacupuncture (EA) and surgical decompression in experimental spinal cord injury due to mechanical compression in dogs.

Materials and Methods

Experimental animals

Healthy 10 male dogs (3.1-5.0 kg and 1-2 years) were assigned into two groups regardless of their body weight and age. The one was decompressive surgery with EA (Group A, 5 dogs), and the other was decompressive surgery alone (Group B, 5 dogs). This study adhered to the strict guidelines of the "Guide for care and use of laboratory animals" of Seoul National university.

Compression material and experimental procedure

Before surgery, the heights of spinal canal and spinal cord were measured with myelography between the 3rd and the 4th lumbar vertebra. According to the measured heights, the compression material of cylindrical shape was made of stainless steel. Its height 5.0 mm and diameter 2.0 mm were decided with result in paraplegia with deep pain perception. The size of compression material was big enough to result in about 40% deviation of spinal cord. The anesthesia was maintained with isoflurane (Aerane, Ilsung Co., Korea). Dogs were placed in sternal recumbency and prepared in routine manner. One cm skin incision was made at about 1.5 cm lateral to the spinous process of the 4th lumbar vertebra. The left pedicle of the 4th lumbar vertebra was exposed by dorsolateral approach. Using 4 mm spheric bur, a hole was made in a cranial pedicle of the vertebra according to the diameter of compression material. The compression material was inserted through the window to compress spinal cord. Subcutaneous fat graft was placed over pediculectomy site. Muscles, subcutaneous layer, and skin were closed routinely. Deep pain perception and complete loss of voluntary movement of hind quaters were confirmed 24 hrs after recovery from anesthesia.

Treatment

Forty eight hours after experimental spinal compression, spinal decompression and removal of compressive material were achieved by left lateral hemilaminectomy. The skin incision was made at left lateral to the dorsal midline from

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the 3rd lumbar vertebra to the 4th lumbar vertebra. The articular process was exposed with dorsolateral approach and the facet joint was severed. Then, left lamina was removed with rongeurs. The length of decompression site was extended until normal epidural fat was visible, and compression material was retrieved. Free fat was grafted onto the spinal cord and the wound was closed. In group A, EA treatment was applied every other days from 48 hrs after decompression to full recovery. GV-4 (*Ming Men*), GV-3 (*Yao Yang Guan*), BL-23 (*Shen Shu*), and BL-24 (*Qi Hai Shu*) were bilaterally used as local points, and GB-34 (*Yang Ling Guan*) and ST-36 (*Zu San Li*) were bilaterally used as distal points. GV-4 (*Ming Men*) as cathode and at ST-36 (*Zu San Li*) as anode was electrically stimulated with 3.5 V, 5 Hz for 20 minutes by using of electrical stimulator (Pulse stimulator AM3000, TEC, Japan).

Evaluation

After decompression, neurological function was evaluated daily by two examiners who were unaware of each animal's treatment group.

A modified Tarlov grading system was used to score hindlimb function as follows[4,16]; Grade 1=complete paraplegia with no hind extremity motion; Grade 2=slight motion; Grade 3=animal can stand; Grade 4=animal can walk; Grade 5=animal can climb stairs without pain, which was considered as normal neurologic state. Neurological examinations were continued until the day when the animal showed the level of grade 4 and grade 5.

SEPs were measured for more objective evaluation of normal spinal cord function with a 'Neuropack 2, MEM-7102' (Nihon Kohden, Tokyo, Japan) and subdermal 'Platinum needle electrodes' (Grass, U.S.A.) before spinal compression and after neurological recovery. Two channels were used. 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. The posterior tibial nerve was stimulated at the point between the tibia and calcanean tendon with 0.2 msec, 2 Hz and 3 mA. SEPs were averaged over 500 times in each recording. Latency and distance from channel 1 to channel 2 were measured, and the latency was converted into the velocity for evaluation of spinal cord functions.

Statistical analysis

Mann-Whitney U test was used to investigate the days taken to retrieve walking ability (Grade 4), clinically normal state (Grade 5), and those of the rehabilitative period from the grade 4 to the grade 5 between the groups. Wilcoxon signed-rank test was used to compare conduction velocities of SEPs before spinal compression and after full recovery.

Results

On neurological examination, paraplegia with deep pain perception was resulted from spinal compression. There was no voluntary movement of pelvic limbs of all dogs just after hemilaminetomy and removal of compression material. It took 10.0 ± 2.7 days (range: 7-14 days) for the dogs in group A to walk. In group B, 13.4 ± 3.7 days (range: 8-18 days) were necessary to recover ambulation. In group A, mean recovery period of normal activity, which was indicated by climbing stairs without pain, was 17.2 ± 3.9 days (range: 13-23 days), and in group B, 34.2 ± 14.5 days (range: 22-56 days). Mean recovery period of normal activity of the group A was significantly shorter than that of group B ($p < 0.05$) (Table 1). The rehabilitation period from ambulation to normal activity of group A was 7.2 ± 1.8 days (range: 5-9 days), and that of group B, 20.8 ± 11.8 days (range: 8-38 days). Mean rehabilitation period of the group A was significantly shorter than that of group B ($p < 0.05$) (Table 1). After induction of spinal cord compression and just after decomressive surgery, SEPs were not detected. The conduction velocity of SEPs was 77.0 m/sec in first experimental dog in group A. After the combination

Table 1. The days required to walk and climb stairs and rehabilitation period from walking to climbing stairs following surgical decompression and EA in spinal cord injury

Group Grade	Recovery days											
	A						B					
	1*	2	3	4	5	Mean	1	2	3	4	5	Mean
4	11	14	7	8	10	10.0±2.7	18	12	14	15	8	13.4±3.7
5	16	23	13	15	19	17.2±3.9[a]	56	26	22	42	25	34.2±14.5[b]
Rehabilitation (Grade 5-4)	5	9	6	7	9	7.2±1.8[a]	38	14	8	27	17	20.8±11.8[b]

*dog number
[a,b]Significantly different between groups ($p<0.05$)
Group A : The combination of EA and surgical decompression
Group B : Surgical decompression
Grade 4 : animal can walk
Grade 5 : animal can climb stairs without pain
Rehabilitation (Grade 5-4) : Rehabilitation period from walking to climbing stairs

Table 2. Conduction velocity of SEPs before the spinal injury and after full recovery from spinal injury.

Group Status	Conduction velocity of SEPs (m/sec)									
	A					B				
	1*	2	3	4	5	1	2	3	4	5
Before[a]	77.0	47.0	60.5	67.2	61.9	69.8	50.0	46.3	48.3	62.5
Post-recovery[b]	77.0	44.1	57.2	57.4	52.8	58.6	42.3	47.6	48.4	51.7

*Dog number
Group A : The combination of EA and surgical decompression
Group B : Surgical decompression
[a]Status before the spinal injury
[b]Status after full recovery form the spinal injury

of EA and surgical decompression, SEPs was measured at 77.0 m/sec. However, conduction velocity of SEPs showed a tendency to return to normal when the recovery was completed. The second dog in groups B was measured at 50.0 m/sec before injury. After recovery in this dog, the velocity was measured at 42.3 m/sec (Table 1). The velocity did not recover completely. Though the velocity of SEPs, It was shown that the combination group of EA and surgical decompression effectively improves the conduction of SEPs.

Discussion

It is generally accepted that decompressive surgery is superior to conservative management, especially for dogs that are in non-ambulatory state. The goal of any treatment for IVDD is to let a patient become an acceptable household pet in terms of bladder control, the ability to walk and freedom from pain[19]. Therefore, the clinical status of dog with experimental spinal disorder has been evaluated with modified Tarlov grading system besides conventional neurological examination[4,18]. In the present study, the modified Tarlov grading system was applied to estimating the neurological function of the dogs with experimentally induced spinal injury, and it was mainly observed if the animal could stand and toddle or walk normally without pain. In this study, the animals in group A (surgical decompression and EA) could walk (grade 4) by 10.0 ± 2.7 days and climb stairs without pain (grade 5) by 17.2 ± 3.9 days after treatment began. The animals in group B (surgical decompression) could walk by 13.4 ± 3.71 days and got full recovery by 34.2 ± 14.5 days after decompression. The time for return to walking was not significantly different between the two groups and was compared very favorably with other clinical studies which were performed to investigate the duration of recovery period after hemilaminectomy[3,6,19]. In previous study, residual deficits such as weakness, ataxia, knuckling, and persistent pain even after patients could walk were reported. These deficits remained long period postoperatively[3]. In the current study, the period of complete recovery of goup A was significantly shorter than group B. SEPs is the method to evaluate the normal spinal cord function before spinal compression and after neurological recovery. The loss of SEPs, neurologic, and histological abnormalities occurred at 50% compression of the cauda equina, but 25% constriction did not revealed abnormal SEPs and neurological signs. The cauda equina that compressed 50% of spinal canal was in the critical point of possible recovery[12]. It is taken into granted that myelography could identify definitively the site of the compressive lesion in all dogs with neurological disease which had localized to the thoracolumbar spine[14,20]. In addition, myelography or angiography has been performed to estimate the extent of spinal cord compression by comparing the diameter of the spinal cord at the point of maximal deviation with that from a corresponding site at an adjacent vertebra[7,21]. In this study, the experiment was preceded by myelography which was carried out to confirm the absence of any spinal cord compression and decide on the size of compression material. About 40% deviation of spinal cord was thought to be proper to ignite paraplegia with deep pain perception. The mechanism of action by acupuncture for disc disease is not yet fully understood. However, analgesic effects, activation of regrowth of destroyed axon in the spinal cord, and rehabilitation of neuromuscular system may be involved in its action[5,11]. The different types of acupuncture techniques was reported in terms of the number of needles[10]. In this study, 4 local points and 2 distal points were used. The stimulation of distal points induces analgesic effect mediated by opioid receptor in brain areas[23] and EA induce isometric muscle contraction which is therapeutic adjuvant in preventing atrophy of hindlimbs[9]. It was demonstrated that changing the frequency of stimulation activated different brain neuropeptides. The endorphins and enkephalins are selectively released into the cerebrospinal fluid by low-frequency electrical stimulation (2-5 Hz). This type of stimulation usually produces analgesia in 10 to 20 minutes and is considered to be cumulative, meaning that subsequent treatments produce better analgesia[8,23]. Although some authors insisted that the frequency from 20 Hz to 30 Hz be used to get analgesic effect in spinal disorder[2,17], EA of low-frequency was performed to achieve analgesic and muscle stimulatory effects in this study. This EA technique was thought to be suitable to long term postoperative management. The present study suggests that the EA therapy after surgical decompression be significantly effective for paraplegia resulted from spinal compression.

Conclusion

This study was performed to evaluate the effects of the combination of EA and surgical decompression on paraplegia resulted from spinal compression in dogs. The animals in group A (surgical decompression and EA) and group B (surgical decompression) regained ambulatory ability (Grade 4) by 10.0 ± 2.7 days and 13.4 ± 3.7 days, respectively. It took 17.2 ± 3.9 days to get full recovery (Grade 5) in group A and 34.2 ± 14.5 days in group B. There was no significant difference between the groups in period of restoring grade 4. However, the period of rehabilitation in group A was significantly shorter than that in group B ($p < 0.05$). According to these results, it was considered that the combination of EA and surgical decompression was more effective than surgical decompression alone for paraplegia with intact deep pain perception ignited by spinal cord injury in dogs.

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개에서 실험적으로 유발한 척수손상에 대한 전침과 감압술의 병용 효과

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요 약: 개에 실험적으로 후구마비를 유발한 후 감압술과 전침술을 병행 처치하였을 때 그 임상적 효과를 알아보고자 본 실험을 실시하였다. 3.15.0 kg, 12년령의 신경계 질환이 없는 임상적으로 건강한 10두의 수캐를 각 5두씩 감압술 및 전침술 병용군 (A군)과 감압술 단독군 (B군)으로 편성하여 각 군의 실험견에 약 40%의 척수압박을 하여 심부통각 지각이 있는 후구마비를 유발하였다. 후구마비 유발 48시간 후, 두 군 모두에 편측추궁절제술을 실시하고 압박물을 제거하였고, 감압술 및 전침술 병용군은 감압 이틀 후부터 회복시점까지 2일에 1회씩 전침 치료를 하였다. 실험기간 중, 매일 Talrov's grading system 변법을 사용하여 임상적 평가를 하였다. 실험전과 치료종료 시점의 체성감각유발전위(SEPs)를 측정하여 측정된 유발전위를 신경전도 속도로 환산하여 신경기능을 확인하였다. 감압술 및 전침술 병용군에서는 술 후 보행능력 회복까지 10.0±2.7일이 걸렸으며, 완전회복까지는 17.2±3.9일이 소요되어 보행능력 회복에서 완전회복까지 7.2±1.8일의 재활기간이 필요했다. 한편 감압술 단독 적용군은 술 후 보행능력 회복까지 13.4±3.7일이 걸렸으며, 완전회복까지는 34.2±14.5일이 소요되어 보행능력 회복에서 완전회복까지 20.8±11.8일의 재활기간이 필요했다. 완전회복 후의 SEPs의 전도속도는 실험전의 정상범위로 회복된 양상을 보였다. 감압술 적용 후, 보행능력 획득까지의 기간은 두 군간에 유의적인 차가 없었으나, 완전회복 및 재활기간에 있어서는 감압술과 전침 병용군이 더 짧은 치료기간을 보였다. 이상의 결과로 보아 개에서 추간판 탈출증에 의한 후구마비가 있는 경우, 감압술과 전침 치료를 병행하면 기능회복 기간을 단축시킬 수 있을 것으로 판단된다.

주요어: 척수손상, 후구마비, 감압술, 전침, 개