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The Effect of Saphenous Nerve Block on the Surgical Stress Induced by Pain Following the Surgical Realignment of Medial Patellar Luxation in Dogs

[1]Woo-Dae Park, [1]Ki-Rae Cho, [2]Young-Sook Lee, [3]Chun Sik Bae and [4]Sung Chul Lim
[1]Department of Veterinary Nurse and Pet Science,
[2]Department of Cosmetology, Seojeong College, 482-133 Yangju, Korea
[3]Department of Veterinary Surgery, College of Veterinary Medicine,
Chonnam National University, 500-757 Gwangju, Korea
[4]Department of Pathology and Research Center for Resistant Cells, College of Medicine,
Chosun University, 501-825 Gwangju, Korea

Abstract: The purpose of this study was to verify the efficacy of a Saphenous Nerve Block (SNB) in the decrease of surgical stress induced by post-operative pain following surgical realignment of the medial patellar luxation in dogs. All subjects were divided into 3 groups according to post-operative analgesic methods: a group with SNB (Sn, n = 5), a group with the intra-articular injection using bupivacaine (Ac, n = 5) and a control group with SNB using saline (Ct, n = 5). Surgical stress from pain was assessed at variable times after surgery using Heart Rate Variability (HRV), a Numerical Rating Scale (NRS) and measurement of blood glucose level. No significant differences in HRV were found between the Sn and Ac groups while there were significant differences between the Ac and control groups. However, the LF of the Sn group was significantly higher than that of the Ct group at 30 min. The values of the NRS in the Ac and Sn groups decreased significantly more than that of the Ct group. However, no statistical differences were found in the NRS between the Ac and Sn groups. There were no statistical differences among the groups in terms of blood glucose levels. Some evidence was found to suggest that SNB for pain reduction after realignment surgery of the medial patellar luxation in dogs is an easy technique to acquire some analgesic effects. However, the single use of SNB for pain control in realignment surgery of the medial patellar luxation is not recommended because of its weak analgesic effects.

Key words: Dog, pain, patellar luxation, saphenous nerve block, surgical stress, Korea

INTRODUCTION

Patellar luxation which is one of the most frequent orthopedic diseases in dogs can result in the development of degenerative joint disease, pain and lameness (Birchard and Sherding, 1994; Fossum *et al*., 2002). However, surgical stress from pain following surgical realignment of the patellar luxation has been controlled only by some methods such as analgesics. Surgical realignment of the patellar luxation in dogs causes severe post-operative pain. Pain control methods such as cryotherapy, electrical stimulation, patient-controlled analgesia, regional anesthesia, preemptive analgesia and intraarticular or peri-articular injections have been used in orthopedic surgery performed on human beings (Rosen *et al*., 2010). Peripheral nerve blocks have been used to avoid systemic side effects associated with opioids and nonsteroidal anti-inflammatory drugs in a lower incidence of secondary cardiovascular, respiratory and gastrointestinal compromise (Rasmussen *et al*., 2006a; Serpell *et al*., 1991).

Among the peripheral nerve blocks, SNB is a block of the saphenous nerve innervating the medial thigh and femoro-tibial joint, its capsule, femoro-tibial joint intraarticular structures, the skin of the dorsomedial tarsus and the 1st digit and proximal aspect of the second digit of the pelvic limb (Rasmussen *et al*., 2006b; O'Connor and Woodbury, 1982; Haghighi *et al*., 1991). When the skin and trochlear in the region of the innervated saphenous nerve were operated on, it was presumed that the post-operative pain would decrease in the SNB. Therefore, the purpose of this study was to determine the post-operative pain control effect of SNB following the surgical realignment of the medial patellar luxation and the degree of decrease in pain compared with intra-articular injection from local anesthetics.

MATERIALS AND METHODS

Subjects: Fifteen small dogs weighing 9.7±0.3 kg with medial patellar luxation (grade~II) were used in this study. The diagnosis of patellar luxation was based upon the

Corresponding Author: Sung Chul Lim, Department of Pathology and Research Center for Resistant Cells, College of Medicine, Chosun University, 501-825 Gwangju, Korea

grade classification of patella luxation during a physical examination (Fossum *et al.*, 2002). The dogs that were certified with grade III~IV were excluded from the experiment. In a preoperative examination, results of the physical examination, serum biochemistry analysis and electrocardiographic examination were normal. Preoperative preparations were followed according to routine procedure. The study was carried out in accordance with the Guidelines for Animal Care and Use Committee of Seojeong College, Korea.

Experimental design: The dogs were divided into 3 groups: the Sn (n = 5) group in which the saphenous nerve of the leg operated on was blocked with bupivacaine 1 mL (Bupivacaine® HCl 0.5%, Myungmoon Pharm., Korea), the Ac (n = 5) group that were injected with bupivacaine 1 mL into an articular cavity of the leg operated on and the Ct (n = 5 serving as a control) group in which the saphenous nerve of the leg operated on was blocked with 1 mL of normal saline.

The dogs were inducted with propofol 1% (Provive™, Claris Lifesciences Limited India) and then maintained on isoflurane (Terrell, Minrad Inc, USA) in 100% oxygen after intubation. To stabilize the patella in the trochlea, a trochlea wedge recession was performed. Following the longitudinal cuts of the lateral skin on the trochlear cartilage, the articular cartilage from the patellar groove was cut to make a V-shaped outline. After removing this bone and articular cartilage, the additional bones from both the trochlear ridge sides were removed to deepen the trochlea groove.

Then the trochlear segment was replaced in the recess, the skin was closed and subcutis by the interrupted suture completed (Birchard and Sherding, 1994). After the skin was sutured, a SNB (Sn and Ct) or bupivacaine injection into the Articular cavity (Ac) was performed. The SNB technique presented by Rasmussen *et al.* (2006a) was used in this experiment. Before anesthetic recovery occurred, bupivacaine 0.5% 2 mg kg^{-1} was injected into the site located at the crossing of 1/2 point of femur and the midpoint between the pectineus muscle and the medial epicondyle of the femoro-tibial joint.

The nerve blocks were performed by a veterinarian with extensive experience of SNB. In the Ct, normal saline was injected using the same method of Sn. The injections between the patella and the trochlea groove were performed in Ac. 0.5% Bupivacaine 2 mg kg^{-1} was injected into the space between the patella and the trochlea cartilage before recovery from the anesthesia occurred.

Surgical stress assessment method: HRV, NRS and blood glucose were used for surgical stress assessment. HRV raw data was obtained every 5 min at the baseline (before anesthesia), 0 (immediately after the post-anesthetic recovery), 30 min, 1, 2, 3, 6, 9, 12, 24 and 48 h after post-anesthetic recovery by Polar S-810i device (Polar Electro Co., Kempele, Finland) and transmitted to a computer for analysis.

This data was filtered to eliminate artifacts by Polar Pro Trainer software (Polar Electro Co.). R-R signals were analyzed into the time domain components and the frequency domain components by HRV analysis software v 1.1 (Biomedical Signal Analysis Group, Kuopio, Finland). The components analyzed in the time domain were Standard Deviation of Normal beats (SDNN), Root Mean Square of the Differences between consecutive R-R intervals (RMSSD) mean Heart Rate (HR) and Triangular Interpolation of NN intervals (TINN). In the frequency domain components Very Low Frequency (VLF), Low Frequency (LF), High Frequency (HF) and the LF/HF ratio were analyzed.

The NRS Method that was suggested by Hellyer and James (1998) was performed by four observers at 1, 3, 6, 12, 24 and 48 h after the completion of surgery. They observed the pain intensity in the dog that had been operated on using 9 items consisting of comfort, movement, appearance, vocalization, heart rate, respiration rate, mental status, walking ability and palpation. A pain score from 0-4 was employed where 0 indicates no pain and 4 very severe pain. The blood collected continuously from the catheter in the cephalic vein at 0, 1, 3, 6, 12 and 24 h was analyzed for blood glucose levels.

Statistical analysis: The data was analyzed with a repeated measure ANOVA followed by a Duncan post-hoc test. $p<0.05$ was considered significant.

RESULTS AND DISCUSSION

Fifteen small dogs with medial patellar luxation classified as grade ~II participated in the study. Dogs diagnosed with patellar luxation classified as grade III~IV were excluded because the saphenous innervation was out of surgical range. In the HRV, there were significant differences in all parameters except the LF/HF ratio when the post-operative values were compared with the values of the baseline in the Ct. The values of SDNN and HF showed significant decreases at 0 and 30 min while the values of the HR showed significant increase between 0 min and 1 h compared to the baseline. The values of RMSSD, TINN and VLF showed significant decreases

Table 1: The comparisons of heart rate variability following the surgical realignment of medial patellar luxation

Parameters	Groups	Baseline	0	30 min	1 h	2 h	3 h	6 h	9 h	12 h	24 h	48 h
SDNN	Ct	0.65±0.07	0.50±0.05*	0.52±0.03*	0.51±0.07	0.55±0.08	0.58±0.11^{a}	0.52±0.06	0.61±0.08	0.61±0.08	0.65±0.120	0.62±0.04
	Sn	0.72±0.07	0.57±0.00*	0.51±0.03*	0.58±0.02*	0.66±0.04	0.67±0.04^{ab}	0.61±0.04	0.70±0.05	0.78±0.08	0.70±0.060	0.77±0.06
	Ac	0.75±0.05	0.58±0.09*	0.41±0.02	0.51±0.03	0.77±0.09	0.80±0.07^{b}	0.75±0.10	0.76±0.08	0.76±0.10	0.86±0.130	0.89±0.07
HR	Ct	96.3±9.100	126.5±14.40*	118.5±9.300^{a*}	126.1±14.90*	118.7±13.40	99.3±15.90	124.6±14.90	106.9±11.30	108.7±12.60	108.70±20.70	98.20±7.2
	Sn	76.3±7.400	125.2±3.000*	121.4±8.000^{ab*}	105.2±4.100*	93.7±7.400	92.2±5.800	101.1±8.500	89.0±7.900	89.8±8.800	89.80±8.900	80.70±7.5
	Ac	82.2±7.200	116.9±20.50	149.2±10.00^{b*}	121.8±8.200	86.5±16.10	79.6±9.600	88.4±13.60	84.7±11.30	78.4±12.80	78.40±13.40	69.80±5.9
RMSSD	Ct	21.18±4.56	7.58±2.08$^{a\ b*}$	12.30±3.53*	13.88±5.03*	15.98±7.11	21.70±5.75	11.96±3.54	19.35±6.37	18.92±4.62	23.06±8.430	19.12±2.57
	Sn	37.96±6.22	4.78±1.44^{a*}	12.24±2.07*	14.58±1.93*	20.88±3.18*	21.94±3.34	15.92±2.93*	24.56±6.06	31.74±7.99	26.08±6.770	29.62±4.93
	Ac	32.90±6.59	18.06±5.53^{b}	8.26±1.74	12.04±1.74	31.16±6.56	36.24±6.79	30.60±9.71	33.44±8.96	32.52±8.94	44.12±14.07	42.24±8.48
RR triangular	Ct	0.08±0.00	0.04±0.01*	0.06±0.01*	0.06±0.01*	0.07±0.01*	0.08±0.01	0.05±0.01*	0.07±0.01*	0.08±0.01	0.09±0.010	0.07±0.00
index	Sn	0.13±0.01	0.03±0.00*	0.07±0.00*	0.07±0.01*	0.08±0.00*	0.08±0.00*	0.07±0.00*	0.08±0.00*	0.10±0.01*	0.10±0.010*	0.10±0.00*
	Ac	0.11±0.00	0.05±0.01*	0.06±0.00*	0.07±0.00*	0.10±0.01	0.12±0.02	0.09±0.01	0.09±0.00	0.08±0.01	0.11±0.010	0.10±0.01
TINN	Ct	209.0±27.20	117.0±24.50*	147.0±35.60*	185.0±41.80*	220.0±58.00	266.0±50.80	159.0±44.70*	181.5±35.70	224.0±44.70	242.00±46.80	211.0±27.4
	Sn	354.0±44.10	122.0±31.70*	183.0±13.80*	205.0±19.80*	227.0±17.70*	266.0±49.20	191.0±25.20*	239.0±35.50*	253.0±32.10*	250.00±35.9*	272.0±31.8
	Ac	314.0±23.70	156.0±22.80*	163.0±23.30*	192.0±15.20	293.0±52.50	342.0±47.50	282.0±58.60	284.0±39.30	242.0±37.50	326.00±60.20	319.0±42.2
LF	Ct	509.4±81.70	62.0±25.30$^{a\ b*}$	79.2±22.80^{a*}	161.0±48.70*	202.8±85.00*	272.0±71.60	138.6±80.70^{a*}	130.7±14.60^{a}	284.8±100.6	348.40±122.5	223.6±36.7
	Sn	664.2±135.4	16.8±11.60^{a*}	180.2±27.50^{b*}	205.2±50.10*	218.4±38.80*	323.6±61.90*	207.6±54.30^{a*}	309.2±78.40^{a*}	436.0±127.7	380.00±118.2*	470.6±91.7
	Ac	561.6±144.8	133.4±53.10^{b}	126.2±25.60$^{a\ b}$	174.0±23.80	334.4±77.10	605.2±164.6	465.4±95.80^{b}	438.2±131.3^{b}	453.2±120.7	840.00±265.7	579.6±110.3
HF	Ct	153.6±14.90	14.6±8.600*	18.8±5.800*	28.8±12.20*	55.8±40.30	47.2±22.40^{a}	20.8±11.60	56.4±27.50	43.7±14.60	88.40±52.80	40.0±10.0
	Sn	143.2±41.30	2.0±0.800*	28.0±6.400*	28.2±5.400*	43.0±5.600	54.2±10.10^{a}	29.2±5.700*	71.4±23.00	131.8±74.00	84.20±43.10	97.0±25.5
	Ac	130.8±41.10	34.0±15.30	14.6±3.200	20.2±3.800	112.0±32.40	173.8±44.60^{b}	100.0±31.40	170.6±76.70	136.6±51.80	211.40±101.5	233.0±125.2
LF/HF ratio	Ct	5.92±0.48	7.44±2.14	4.47±0.74	6.87±1.25	7.28±1.70	8.21±2.03	5.66±1.25	4.07±0.91	6.41±0.22	5.42±1.320	6.01±0.48
	Sn	5.28±0.72	5.72±2.13	8.96±3.69	7.15±0.44	5.35±1.08	6.37±1.43	6.77±0.57	5.00±0.66	5.56±1.43	7.28±2.010	5.73±1.21
	Ac	5.68±1.57	4.78±1.06	10.29±2.42	9.67±1.84	4.02±1.09	4.16±0.87	5.79±1.02	3.59±0.63	4.42±1.24	7.27±2.700	4.22±1.20

SDNN: Square root of variance of' all R-R intervals; HR: Heart Rate; RMSSD: Root Mean Square of Successive Differences of R-R intervals; RR triangular index: Normal beat to normal beat triangular index; TINN: Triangular Interpolation of NN intervals; LF: Low Frequency; HF: High Frequency; LF/HF ratio: Low Frequency/High Frequency ratio; Sn: Group Saphenous nerve block; Ac: Group intraarticular injection using bupivacaine; Ct: Group control; ^{ab}Means with different letters are statistically different among groups ($p<0.05$); *Significantly different from baseline values ($p<0.05$)

between 0 and 1 h and the RRTRI and LF showed significant decreases between 0 and 2 h compared with the baseline. In the Sn, there were significant differences in all parameters except for the LF/HF ratio; the values of SDNN, RMSSD, PNN50 and HF significantly decreased between 0 min, 1 and 6 h compared with the baseline (Table 1).

The values of RRTRI, VLF and LF significantly decreased over all time intervals except that of 48 h compared with the baseline. The values of TINN significantly decreased in all time intervals except that of 3 and 48 h compared with the baseline. The Ac showed insignificant differences in RMSSD, VLF, LF, HF and LF/HF compared with the baseline with the exception that there were significant decreases the value of SDNN at 30 min in the value of RRTRI between 0 and 1 h and in the value of TINN between 0 and 30 min compared with the baseline.

The value of HR significantly increased at 30 min compared with the baseline. In comparisons of HRV parameters among groups, the SDNN of the Ac group was higher than that of the Ct group at 3 h and the HR of the Ac group was higher than that of the Ct group at 30 min. There were no significant differences in RMSSD, RRTRI, TINN, VLF and LF/HF ratios among the groups. The LF of the Sn group was significantly higher than that of the Ct group at 30 min and in the Ac group it was significantly higher than that of the Sn and the Ct groups at 6 and 9 h. The HF was significantly higher in the Ac group than in the Ct and Sn groups at 3 h. Regarding the blood glucose level, the blood glucose of the Sn group significantly decreased compared

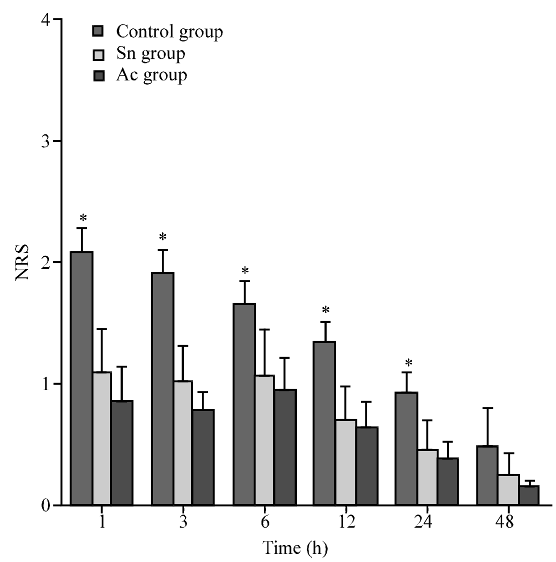

Fig. 1: The Numeric Rating Scale (NRS) score among groups: there were significant differences in the Sn group and the Ac group compared with the Ct group between 1-24 h (*$p<0.05$); Ct: Control; Sn: Saphenous nerve block; Ac: Intraarticular injection using bupivacaine; Time: Hour after surgery end

to that of the Ac group at 1 h. There were no significant differences in the other times among the groups. The NRS showed that the value of the Ct group more significantly increased than that of the Ac and the Sn groups between 1 and 24 h. The value at 48 h decreased in the Ac group compared with the Ct group but there were no statistical differences (Fig. 1).

The saphenous nerve arises in the femoral nerve in a femoral triangle and descends through it on the lateral side of the femoral vessels to enter the adductor canal. It lies on the medial side in front of the lower end of the adductor magnus muscle and then continues its descent on the medial side of the knee. The saphenous nerve supplies the skin over the medial side and front of the knee and patellar ligament (Rasmussen *et al.*, 2006a, b). This study was performed to verify the hypothesis that the blockade of the saphenous nerve distributed on the medial knee joint could decrease the post-operative pain following the patellar realignment surgery of the medial patellar luxation. Consequently, this study showed a clinical advantage in that the SNB contained some effective methods for post-operative pain decrease following realignment surgery of the medial patellar luxation. To verify the hypothesis in this study, HRV, NRS and blood glucose were measured in assessing the effects of pain control. HRV is used for measurement of autonomic nervous functions that generally can be altered by pain. HRV is divided into a time domain and a frequency domain. In the time domain, SDNN and RMSSD reflect the complexity and safety of the heart and SDNN also is decreased by acute stress such as pain (Camm *et al.*, 1996).

Both parameters did not show statistical differences between the Ct and Sn groups. However, the Ac group showed statistical differences at 3 h compared with the Ct group. The values of the Sn group at 3 h were between the Ct and Ac groups. These results showed that SNB has a small effect on the safety and complexity of the heart and is less effect than the intra-articular injection using bupivacaine. The RR triangular index and tinn are based on the geometric and/or graphic properties of the resulting pattern which are more influenced by the lower than by the higher frequencies (Camm *et al.*, 1996; Malik *et al.*, 1989). Both parameters showed statistical indifferences among groups.

However, the Sn group showed a statistically longer action time than the other group compared with each baseline. Because the RR triangular index and tinn indicate the activity of sympathetic nerves these results showed that SNB could decrease the activity of sympathetic nerves induced by post-operative pain over a longer period of time. In the frequency domain, the LF components are considered markers of sympathetic and parasympathetic nerve activities and are decreased by fatigue (Camm *et al.*, 1996; Saul *et al.*, 1988). The HF component is considered as a marker of parasympathetic nerve activity and the LF/HF ratio is considered to be an index of sympathetic nerve activity (Matsubara *et al.*, 2011). The results showed that all parameters in the Sn group, except for the LF/HF ratio, were significantly altered while there were no significantly changes in all the parameters in the Ac. The LF component of the Sn group was significantly higher than that of the Ct group at 30 min and the Ac group was significantly higher than that of the Sn and Ct groups at 6 and 9 h.

The HF component was significantly higher in the Ac group than in the Ct and Sn groups. These results show that intraarticular injection using bupivacaine suppress mainly sympathetic nerves but SNB suppresses both sympathetic nerves and parasympathetic nerves.

The values of the LF/HF ratio compared among the groups showed no significant difference but that of the Sn group was in between that of the Ac and Ct groups. This result can be explained by the local anesthetic time and the nerve block time. Autonomic nerves can be altered not only in post-operative pain but also in various factors such as the mental load and environmental conditions. Researchers think that the LF/HF ratio value of the Sn group decreased more than that of the Ct at 2 h. After 3 h, the change in autonomic nerves through pain following the adaptation of the post-operative conditions such as fear and an unfamiliar environment can be measured. After 3 h because the effect of SNB or intraarticular injection using bupivacaine disappears, the values of LF/HF ratio are similar to each other.

The methods for the evaluation of post-operative pain in veterinary medicine assess the mobility and the pain area, Biodynamic, Hematological and Objective Observation Method (Choi *et al.*, 2004). The Objective Observation Methods from among these are the Visual Analogue Scale (Murin and Rosen, 1985; Dobromylskyj *et al.*, 2000), Simple Descriptive Scale (Dobromylskij *et al.*, 2000; Gaynor and Muir, 2002), Multifactorial Scale (Dobromylskij *et al.*, 2000) and Numeric Rating Scale (Hellyer and James, 1998). In the NRS, the Objective Observation Method evaluates the degree of pain consisting of 9 items scored from 0~3. The NRS in this study was undertaken by 4 persons in order to gain objective results and the scores were calculated with the average values between 0 and 3.

The NRS value of the Ct group was statistically higher than that of the of Sn and Ac groups while there were no statistical difference between the Sn and Ac groups. The values for the Sn and Ac groups at 6 h increased more than at 3 h. These results were thought to occur because the pain was increased through a decrease in the effects of SNB and the intra-articular injection using

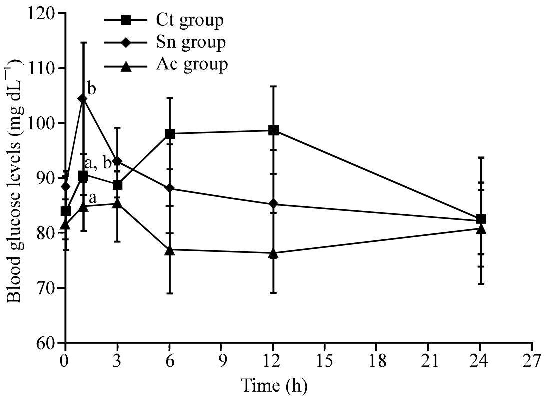

Fig. 2: The graph showing the changes of blood glucose level among groups: there were significant differences between the Ac group and Sn group 1 h (*$p<0.05$). After 6 h, the blood glucose levels of the Ac and the Sn group decreased more than that of the Sn group but there were not significant differences between 6 and 24 h; Ct: Control; Sn: Saphenous nerve block; Ac: Intraarticular injection using bupivacaine; 0: Before surgery; Time: Hour after surgery end

bupivacaine. The hyperglycemic response is an important feature of surgical stress in cases such as surgical trauma and post-operative pain (Traynor and Hall, 1981). Because this hyperglycemic response is induced by the increases of catecholamine and cortisol and by the decrease of insulin secretion, the measurement of the blood glucose indicate indirectly the degree of the pain from surgery (Haxholdt *et al*., 1981).

The blood glucose values showed that the values of the Sn and Ac groups were only increased between 1 and 4 h compared with preoperative values whilst the value of Ct group increased the entire time compared with the preoperative values (Fig. 2). These results correspond to the Downing *et al.* (1986) report that peak cortisol concentration is reached at 1~4 h after surgery and the Lush *et al*. (1972) and Longnecker and Murphy (1997) report that the blood glucose level after surgery was significantly increased compared with the blood glucose level before surgery.

Researchers could not explain the result in this study that the blood glucose level at 1 h significantly increased in the Ac group compared with the Sn group. However, Madsen *et al.* (1977) and Rutberg *et al.* (1984) report that sufficient analgesic administration prevents the increases of serum cortisol and blood glucose. Researchers think that the blood glucose at 1 h was increased because intraarticular injection using bupivacaine decreased post-operative pain but did not inhibited sufficiently the adrenocortical response after the surgery.

CONCLUSION

SNB offers some analgesic effects on pain control after surgical realignment of medial patellar luxation in dogs. However, because its effect is weak, single use of SNB for pain reduction for surgical realignment of medial patellar luxation in dogs is not recommended.

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