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Clinical efficacy of procedural sedation combined with femoral and sciatic nerve blocks for stifle and tibial surgeries in dogs

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The term procedural sedation (PS) is now popular in human anaesthetic practice where a semi-conscious state is achieved allowing the patient to be comfortable during certain therapeutic and diagnostic procedures. This raised the question of whether PS could be used in conjunction with local/regional anaesthesia in veterinary practice, to provide adequate conditions suitable for performing orthopaedic surgeries. Ten adult dogs posted for surgeries of tibia or stifle were used for the study. All the dogs were premedicated with meloxicam (0.2 mg/kg). 30 min later, all the animals were administered intramuscularly with a combination of dexmedetomidine (2 mcg/kg), butorphanol (0.2 mg/kg) and midazolam (0.2 mg/kg). Upon sedation, a loading dose of propofol (0.5 mg/kg body wt) was administered intravenously, followed by an intravenous infusion of propofol (70-150 mcg/kg/min) to maintain the sedation, till the end of surgery. Oxygen was supplied via nasal prongs at a flow rate of 6 L/min. Femoral and sciatic nerve-blocks were then achieved by injecting a combination of dexmedetomidine and bupivacaine for each nerve, through anatomical landmarks, employing a Nerve Stimulator-Mapper-Locator. Procedural sedation combined with femoral and sciatic nerve blocks provided excellent analgesia and muscle relaxation for orthopaedic procedures in stifle joint and structures distal to it. In six animals, nociception was noticed when the bone was drilled, or when the surgical incision was extended proximal to stifle, which could be managed by supplementing analgesic dose of ketamine (0.5 mg/kg body wt, i.v.). The protocol maintained normal mean arterial pressure, oxygenation and ventilatory status of patients. From this study it was concluded that the protocol of PS combined with femoral and sciatic nerve blocks was effective for stifle and tibial surgeries in dogs without compromising cardiopulmonary functions.

Key words: *Dog, Femoral nerve block, Procedural sedation, Sciatic nerve block, Stifle surgery, Tibial surgery*

The term 'procedural sedation' is now popular in human anaesthetic practice where a semi-conscious state is achieved, which allow the patients to be comfortable during certain surgical and diagnostic procedures (Campoy *et al*., 2012). The procedural sedation (PS) is now being combined with loco-regional anaesthesia to provide adequate conditions suitable for orthopaedic surgeries in humans. The level of sedation was reported adequate to perform surgery without the patient attempting to move purposefully, while at the same time breathing spontaneously, without airway support and maintaining ideal cardiovascular functions (Campoy *et al*., 2012). In small animal practice, orthopaedic surgeries are almost always done under general anesthesia using a combination of injectable and inhalant anaesthetic drugs, where the doses of anaesthetic drugs required would be high to maintain surgical anaesthesia to perform such extremely painful procedures. When done so, there will be depression of the myocardial and pulmonary functionswhichneed to be monitored very closely and addressed properly from time to time. Like in human counterparts, PS combined with nerve blocks for regional anaesthesia could be used as an alternative to general anaesthesia for orthopaedic surgeries in small animals (Campoy *et al*., 2012). Hence, the present study was undertaken to evaluate the clinical efficacy of femoral and sciatic nerve blocks combined with PS for surgeries of stifle and tibia in dogs.

Materials and Methods

The study was conducted in 10 dogs with health status classified as ASA I, presented for tibial or stifle surgeries (Table 1). The dogs comprised of two females and eight males, and aged between 6 m and 6 yr, with body weight ranging from 8.4 to 34 kg. Appropriate preoperative fasting was done in all dogs prior to surgery.

Meloxicam was administered (0.2 mg/kg body wt, i.m.), as a pre-emptive analgesic. 30 min later, sedation was achieved using a combination of dexmedetomidine (2 mcg/kg), butorphanol (0.2 mg/kg) and midazolam (0.2 mg/kg) mixed in a single syringe and administered intramuscularly. Sedation was judged as animal attaining sternal recumbency with head down or lateral recumbency. Upon sedation, a loading dose of propofol (0.5 mg/kg body wt) was administered intravenously, followed by a continuous rate infusion (CRI) of propofol (70-150 mcg/kg/min) was administered intravenously using a volumetric infusion pump. The rate of propofol was titrated to provide a moderate level of sedation,

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judged by clinical signs. Oxygen was supplied from the anaesthesia machine through nasal prongs at a flow rate of 6L/min. Nerve stimulator (Fig. 1) guided femoral and sciatic nerve blocks were carried out, through anatomical landmarks such as femoral triangle (Fig. 2) and at the junction of cranial and middle one third of a line drawn from greater trochanter to ischiatic tuberosity (Fig. 3), respectively. A combination of dexmedetomidine (0.1 mcg/kg) and bupivacaine (0.5 mg/kg) were administered perineurally at each nerve through the insulated needle (Fig. 4).

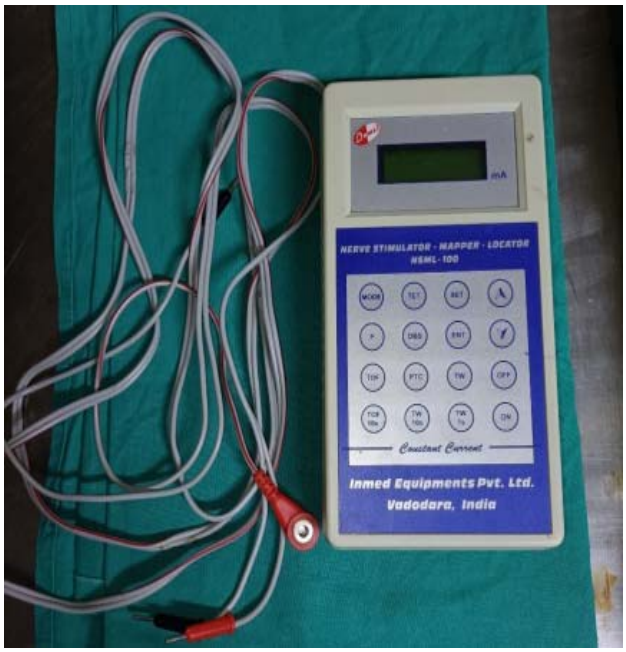

Fig. 1: Nerve stimulator

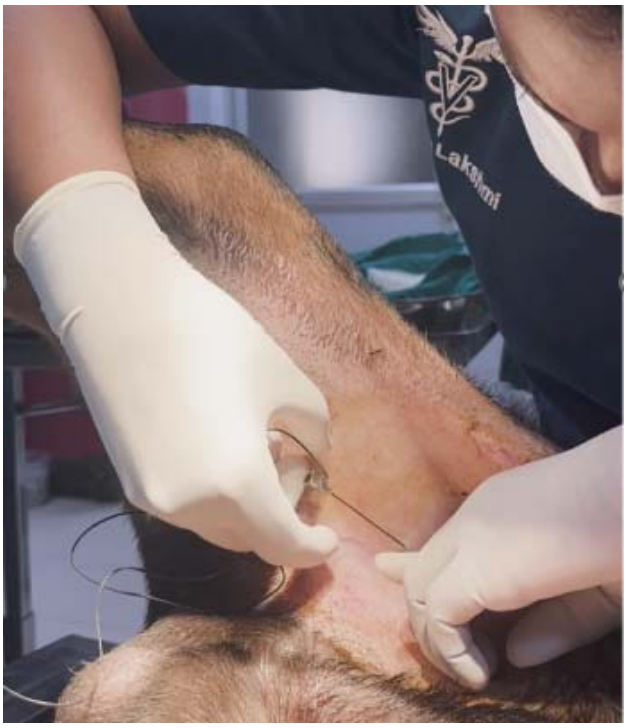

Fig. 2: Anatomical landmark, femoral triangle

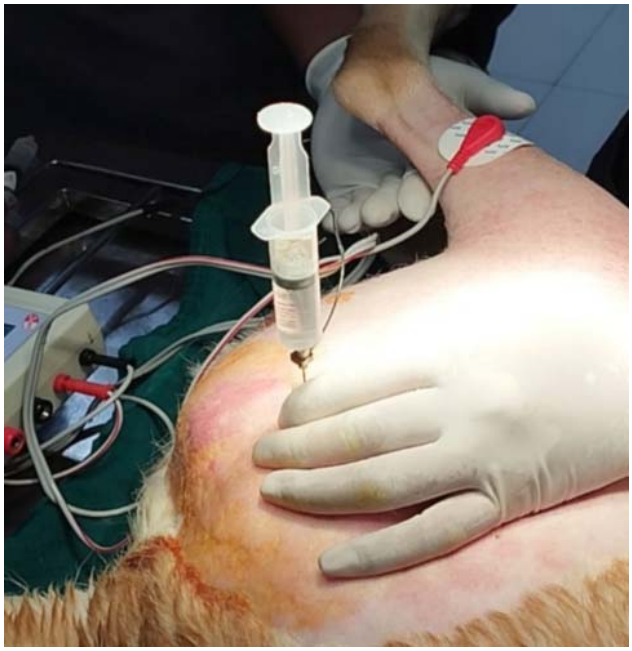

Fig. 3: Location of sciatic nerve block

Fig. 4: Insulated needle

Intraoperative nociception noticed, if any, was managed by micro dose(s) of ketamine administered intravenously. The quantity of ketamine thus administered was noted and recorded.

All the animals were observed for their sedation, intraoperative analgesia, and recovery. Physiological parameters such as heart rate, pulse rate, respiratory rate and rectal temperature were recorded before premedication, immediately following sedation and every 10 min thereafter till recovery.

Venous blood gas analysis was performed immediately before sedation, after sedation and after recovery. Serum biochemistry was evaluated during preoperative assessment and after recovery from sedation. Electrocardiogram was recorded during preoperative assessment of the patient, following sedation and every 10 min thereafter till recovery.

The data were expressed as mean±SE and were analysed statistically using appropriate tests.

Results and Discussion

Signs associated with sedation were head movements (n=5) ptosis, head down, sternal recumbency and lateral recumbency (n=10). The time taken for ptosis (n=10) was 3.6±0.39 min. The time

Table 1: Signalment of the animals studied and their surgical conditions

Dog ID	Breed	Age	Sex	Body weight (kg)	ASA class	Temperament	Surgical procedure / surgical condition
D1	Siberian Husky	1.5 yr	male	21	I	excited	Trochlear wedge recession sulcoplasty (TWRS)
D2	German shepherd	1 yr 1 m	female	20	I	calm	tibial fracture - IM pinning + wiring
D3	German shepherd	8 m	male	24.3	I	excited	tibial fracture - IM pinning + wiring
D4	German shepherd	1.5 yr	female	24	I	calm	tibial fracture - IM pinning + wiring
D5	German shepherd	6 yr	male	28.5	I	calm	tibial fracture - IM pinning
D6	Dachshund	6 yr	male	8.4	I	calm	tibial fracture - IM pinning
D7	Doberman pinscher	5 yr	male	19.3	I	anxious	amputation
D8	Labrador Retriever	6 m	male	29	I	anxious	tibial fracture - IM pinning
D9	Labrador Retriever	7 m	male	27.4	I	docile	TWRS, tibial tuberosity transposition
D10	Labrador Retriever	3 yr	male	34	I	calm	TWRS

taken for head movements (n=5) ranged from 2 to 5 min. The time taken for head down (n=10) following intramuscular administration of the drug combination was 8.5±1.20 min. The time taken for attaining sternal recumbency (n=10) following injection of the drug combination was 6.9±1.41 min. The time taken for sedation was 9.1±1.23 min (Table 2).

These signs were similar to the observations made by Narayanan *et al.* (2011) who have also observed winking of eyes, incoordination of movement, head down and sternal recumbency in dogs premedicated with xylazine-glycopyrrolate, midazolam for ketamine anaesthesia. The time taken for attaining lateral recumbency (5-15 min) was almost similar to that reported by Barletta *et al*. (2011) for dexmedetomidine-ketamine-opioid combination (4-6 min).

Quality of PS achieved with the administration of dexmedetomidine, butorphanol, midazolam and propofol was judged excellent in all the animals studied. All the animals were in moderate level of sedation, from which an arousal could be generated by an external stimulus from regions other than the dermatomes served by loco-regional blockade. The findings of the current study were similar to the observations reported by Campoy *et al*. (2012) in their study, where auto-adhesive drapes and drape to drape towel clamps were employed to avoid arousal from sedation due to similar external stimuli.

Pedal reflex persisted in unblocked limbs throughout the duration of PS and it was abolished in blocked limb of all animals. The result was in accordance with observations made by Campoy *et al.* (2012). Absence of pedal reflex in the desensitized limb and presence of pedal reflex in unblocked limbs proved the efficacy of nerve blockade and evidence for maintaining a state of sedation rather than a surgical plane of general anaesthesia.

Palpebral reflex, jaw tone and gag reflex persisted throughout the duration of PS. Palpebral reflex was present in all the 10 animals studied. Seliskar *et al.* (2007) also reported presence of mild corneal and palpebral reflexes throughout the duration of anaesthesia with propofol-ketamine combination thus giving a doubt whether the anaesthesia was deep enough to perform major surgeries. Spontaneous blinking was observed by Campoy *et al*. (2012) in the study of PS with an intravenous infusion of propofol (0.07–0.15 mg/kg/min) and dexmedetomidine (1 mcg/kg/hr) combined with femoral and sciatic nerve blocks in dogs. Similar observations in the current study substantially support the proof of PS with the drug combination. All the animals had their eyeballs positioned central to partial ventromedial during the period of PS, which could be attributed to the sedative effects of the drug combination. Campoy *et al*. (2012) observed similar finding in their study. Jaw tone and gag reflex persisted in all animals under this study. This finding was contrary to the observation of the absence of jaw tone in the surgical plane of general anaesthesia (Kennedy and Smith, 2014). Thus, we could conclude that the animal was in a state of sedation only rather than general anaesthesia.

Muscle relaxation was excellent in the desensitized limb of all the animals under study. The profound muscle relaxation can be attributed to the combined effects of PS and nerve blocks. Similar observation was made by Campoy *et al*. (2012).

The quality of maintenance of PS was judged as excellent, based on the muscle relaxation, maintenance of physiological parameters such as effortless, spontaneous and regular respiration with normal thoracic exertions, haemodynamic stability and absence of surgical stimuli in surgical limit. The quality of PS in the current study was similar to the results obtained by Campoy *et al*. (2012). PS was

Table 2: Signs associated with sedation and time taken for sedation.

Dog ID	Signs preceding sedation and their respective time from administration of the anaesthetic combination						Quality of procedural sedation
	Salivation (min)	Ptosis (min)	Head movements (min)	Sternal recumbency (min)	Head down (min)	Time taken for sedation (min)	
D1	Not exhibited	3	12	14	14	15	excellent
D2	Not exhibited	2	2	4	10	10	excellent
D3	Not exhibited	6	Not exhibited	14	15	16	excellent
D4	Not exhibited	4	Not exhibited	2	6	7	excellent
D5	Not exhibited	4	Not exhibited	4	7	7	excellent
D6	Not exhibited	2	3	3	4	4	excellent
D7	Not exhibited	3	Not exhibited	5	5	6	excellent
D8	Not exhibited	3	4	6	6	7	excellent
D9	Not exhibited	4	8	11	11	11	excellent
D10	Not exhibited	5	Not exhibited	6	7	8	excellent
Mean±SE		3.6±0.39		6.9±1.40	8.5±1.20	9.1±1.23	

maintained using propofol CRI for a period of 124-244 min with a mean±SE value of 182.3±11.21 min depending on the duration required for the respective surgeries. CRI dose of propofol ranged from 65.09 to 120 mcg/kg/min with a mean±SE value of 93.13±4.53 mcg/kg/min. The CRI dose depended on duration of the procedure and the body weight of animal. The total quantity of the local anaesthetic used for nerve blocks in each animal depended on the body weight of the animal and the number of nerve blocks.

Signs associated with recovery were return of eyeballs to central position, head lift, sternal recumbency and standing up unassisted. The time taken for return of eyeballs to central position (n=10) from the time of weaning of CRI was 4.6±1.33 min. The time taken for head lift (n=10) was 9.00±2.52 min. The signs observed for complete recovery were the time taken for attaining sternal recumbency and standing up unassisted. The time taken for attaining sternal recumbency (n=10) was 15.5±4.35 min. The time taken for standing unassisted (n=10) after termination of CRI was 23.6±5.21 min. The mean time taken for recovery was 9.0±2.52 min (Table 3). This wide range in duration of recovery might be due to difference in patient specific innervations such as branches of the obturator nerve, periosteal nerves, cutaneous femoral nerve, nerves in the interosseous space, and innervations of bone marrow adipose tissue (Zhang *et al*. 2021). Administration of ketamine for antinociception in some patients decreased arousal and recovery. In one animal (D2), the recovery time varied widely to 30 min because it had more nociception requiring administration of more dose of ketamine as compared to others. Along with this, the effect of CRI, which was terminated only after bandaging (at that time there was no nociception), decreased arousal in that animal (Sooryadas *et al*., 2019).

Quality of recovery was judged as smooth in all the 10 animals studied. None of the animals exhibited vocalization or dysphoria, unresponsive to operated limb manipulation while bandaging. They supported themselves in sternal recumbency 15.5±4.35 min after termination of CRI. Campoy *et al*. (2012) have also had similar results in their study of PS combined with femoral and sciatic nerve block.

Six dogs exhibited signs of nociception when the incision had to be extended far proximal to stifle, drilling intramedullary pin in tibial diaphysis. Signs of nociception noticed were increase in heart rate, respiration, position of eyeball from partial ventromedial to central, and head lift. These observations were in accordance with findings of Vettorato *et al*. (2012) and Cathasaigh *et al*. (2018). They have reported that the saphenous nerve and branches from obturator and lateral cutaneous femoral nerves that provide sensory input to the pelvic limb may be missed even if the femoral nerve is accurately identified and blocked at femoral triangle, resulting in a partial or failed block depending on the nature of the surgical procedure and a patient's specific innervation. Nociception was managed with ketamine (0.5 mg/kg) administered intravenously.

Rest of the dogs did not show any sign of nociception when the surgical procedures were limited to surgical limits only (stifle joint and structures distal to it). Those animals were not showing any pain while clamping on the skin of desensitized region (sensory blockade) and knuckling noticed after recovery (motor blockade). Similar findings were observed by Trein *et al*. (2016) while evaluating the effects of dexmedetomidine combined with ropivacaine on sciatic and femoral nerve blockade in dogs. The animals in this study were comfortable without vocalization, delirium, unresponsive to surgical stimulus perioperatively,

Table 3: Time taken for recovery and quality of recovery.

Dog ID	Time taken for signs of recovery following termination of continuous rate infusion of propofol					Duration of maintenance of procedural sedation (min)	Quality of recovery
	Return of eyeballs to centre (min)	Head lift (min)	Sternal recumbency (min)	Standing unassisted (min)			
1	4	6	10	14	6	194	Smooth
2	16	30	33	44	30	178	Smooth
3	3	12	12	16	12	221	Smooth
4	2	2	7	13	2	124	Smooth
5	6	10	46	61	10	173	Smooth
6	2	4	9	15	4	180	Smooth
7	3	5	5	10	5	135	Smooth
8	2	4	3	13	4	180	Smooth
9	3	9	19	25	9	244	Smooth
10	5	8	11	25	8	194	Smooth
Mean±SE	**4.6±1.33**	**9±2.52**	**15.5±4.35**	**23.6±5.21**	**9±2.52**	**182.3±11.21**	

unresponsive to touch on blocked limb postoperatively. These observations were in accordance with findings of Campoy *et al*. (2012).

There was a significant (P<0.05) reduction in rectal temperature (RT) intraoperatively during the period of maintenance of PS in all the animals. The decrease in RT could be attributed to peripheral vasodilation occurred as a result of combined effect of propofol CRI and the second phase of biphasic response of dexmedetomidine, decrease of basal metabolic rate and depression of thermoregulatory mechanism (Koc *et al*., 2002). Seliskar *et al*. (2007) also observed a similar progressive decrease in core body temperature in medetomidine premedicated dogs undergoing anaesthesia with ketamine-propofol combination. Narayanan *et al*. (2011) had a similar finding of marginal decrease in RT, during the period of anaesthesia with glycopyrrolate-xylazine-midazolam-ketamine, which was attributed to the CNS depressant effects of anaesthetic agents. In the current study, even if there was a progressive reduction in RT, the animals maintained it between 34.8℃ and 39, similar to the findings of Barletta *et al.* (2011).

There was a significant reduction (P<0.01) in heart rate (HR) and pulse rate in all the 10 animals studied, when compared to baseline values. The decrease in HR could be attributed to the reflex response to peripheral vasoconstriction induced by dexmedetomidine. Murrell and Hellebrekers (2005) have also mentioned that $_2$ agonists could trigger the occurrence of potent cardiovascular effects such as physiological increase in blood pressure and reflex bradycardia concurrent with decreased cardiac output. Barletta *et al.* (2011) also reported that there was bradycardia in dogs anaesthetised with dexmedetomidine-ketamine-opioid combination, but blood pressure was well maintained in all animals studied. The authors attributed the initial bradycardia as a reflex response to peripheral vasoconstriction induced by dexmedetomidine, and bradycardia during recovery was attributed to the lack of further surgical stimulation and reduced sympathetic outflow. Anikshit (2020) also reported similar finding of reduced HR and pulse rate, when compared to the baseline values, throughout the anaesthetic procedure performed with dexmedetomidine.

Even though there was reduction in HR, the mean arterial pressure (MAP) ranged from 86-100 mmHg, similar to the findings of Bright *et al.* (2002). Campoy *et al*. (2012) who observed no difference in MAP immediately before and after the start of surgery in dogs which underwent PS with an intravenous infusion of propofol (0.07–0.15 mg/kg/min) and dexmedetomidine (1 mcg/kg/hr) combined with femoral and sciatic nerve blocks. Sinus arrythmia was observed in 4/10 dogs studied, at different time periods, although sinus arrhythmia is reported to be normal in dogs (Tilley, 2016).

Respiratory rate (RR) reduced following sedation in all the dogs. RR before sedation ranged from 16 to 28 breaths/min in 8 dogs, but rest of the two dogs were panting. During PS, the RR ranged from 10 to 28 breaths/min and the character of respiration in all animals was ideal with normal thoracic exertions. The animals were taking sighs at intermittent intervals, which indicated that there was no respiratory depression. According to Caroll *et al*. (2008) anaesthesia depresses the ventilatory responses to P_aCO_2, normally the primary drive to breath is increase in P_aCO_2; in conscious patients the control is very sensitive. So, animals will sigh spontaneously only when the increase in PCO_2 can be identified as their own, this property is attributed

only to those animals which are in a conscious or semiconscious state. This phenomenon proved that the respiratory center of brain is not depressed in animals of this study.

The peripheral oxygen saturation of Hb (SpO_2) in all the animals was above 98% during maintenance and following PS. According to oxy-haemoglobin dissociation curve, only a P_aO_2 value nearly 98 mm Hg can provide a SpO_2 value of 98%. Oxygen is present in the body in two forms, bound form (in Hb) and dissolved form (in blood). If there is no optimum P_aO_2 the dissolved oxygen content will be less, which in turn cause unloading of oxygen from Hb thereby decreasing SpO_2. In the current study SpO_2 values were always higher that 98 mmHg. From the correlation between SpO_2 and P_aO_2 it could be assumed that there was optimum P_aO_2 in the blood confirming adequate organ perfusion. DeMeulenare (2007) reported that peripheral vasoconstriction can cause lower SpO_2 values. In the current study the SpO_2 values were higher than 98 mmHg indicating that the vasoconstrictor effect of dexmedetomidine got nullified by the vasodilatory effect of propofol (Kim *et al*., 2017).

The mean ±SE values of partial pressure of oxygen in venous blood in the animals were 43.33±4.40 mmHg before sedation, 51.86±4.42 mmHg after 30 min of sedation and 37.91±1.29 mmHg after recovery from sedation. The venous oxygen values after sedation were higher than that of the baseline, and this could be attributed to breathing a combination of room air and oxygen from the nasal cannula, which delivered oxygen at a flow rate of 6L/min that could provide 44% inspired fraction of oxygen (Fuentes and Chowdhury, 2022). Venous oxygen tension values after recovery were significantly low ($P<0.05$) in all animals compared to that of baseline. The venous oxygen tension alone does not provide accurate information on oxygenation status of patient; venous blood gas plus pulse oximetry can provide more accurate information on oxygenation status (Ogele and Lang, 2018). In the current study, the pulse oximetry values were 98% and above in all the animals indicating that the animals were adequately oxygenated. According to oxy-hemoglobin dissociation curve, a P_aO_2 less than 60 mmHg will cause rapid dissociation of oxygen from Hb by decrease in SpO2 level. If the SpO_2 value is 98% and above, then the P_aO_2 value will be nearly 100 mmHg. According to Zeserson *et al*. (2018) and Prasad *et al*. (2023) there is no correlation between arterial and venous oxygen tensions.

The mean±SE values of partial pressure of carbon dioxide in venous blood ($P_VCO_{2)}$ were 36.39±2.51 mmHg before sedation, 38.62±2.23 mmHg 30 min after sedation and 39.96±1.93 mmHg after recovery, with no significant difference at different intervals, and the values were within normal limits indicating that the ventilatory status of the animals was excellent. The animals were taking sighs intermittently, which indicated that the threshold for detection of increase in P_vCO_2 was low in animals of this study. This property is attributed only to those animals in conscious or semiconscious state, while in anaesthetised animals it will be high. These observations indicated that there was no respiratory depression in any of the animals of this study.

The mean±SE values of pH of venous blood were 7.39±0.02 mmHg before sedation, 7.35±0.02 mmHg 30 min after sedation, and 7.32±0.02 mmHg after recovery, with no significant difference at different intervals. The mean±SE value of bicarbonate of venous blood in the animals before sedation was 20.75±0.55 mmoL/L, 30 min after sedation was 20.62±0.56 mmoL/L and after recovery was 20.74±0.77 mmoL/L, with no significant difference at different intervals.

The mean±SE values of alanine amino transferase before sedation and after recovery were 34.00±4.95 IU/L and 33.3±4.29 IU/L, respectively, with no significant changes. The mean±SE values of total protein also did not vary significantly before sedation (6.03±0.27 g/dL) and after recovery (5.81±0.31 g/dL). The mean±SE value of albumin in the animals before sedation (2.63±0.11 g/dL) and after recovery (2.48±0.12 g/dL) also did not vary significantly. The mean±SE glucose values after recovery (103.14±3.5 mg/dL) were significantly higher ($P<0.05$) in all the animals when compared to the values before sedation (82.36±4.7 mg/dL). Increase in blood glucose level has been observed with use of $_2$ agonists (Restitutti *et al*., 2012; Ansari *et al*., 2019), which was attributed to decreased insulin release from pancreatic cells and decreased utilisation of glucose. Administration of ketamine could also increase blood glucose levels due to an increase in sympathetic tone and resultant increase in norepinephrine levels in blood. Increased sympathetic tone can cause increase in rate of glycogenolysis and gluconeogenesis and decreased insulin production (Thakur *et al*., 2011).

In conclusion, procedural sedation combined with femoral and sciatic nerve blocks provided excellent analgesia and muscle relaxation for orthopaedic procedures in stifle joint and structures distal to it. Some animals exhibited signs of nociception while drilling the bone, manipulation of fracture fragments or while drilling on the bone, even after successful blockade of femoral and sciatic nerve nerves. This nociception could be easily managed by supplementing ketamine (0.5 mg/kg) intravenously. The protocol of sedation and loco-regional block maintained normal mean arterial pressure, oxygenation and ventilatory status in the patients studied. Thus, the protocol of procedural sedation combined with femoral and sciatic nerve blocks, was effective for stifle and tibial surgeries in dogs without compromising cardiovascular and respiratory functions.

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