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Development of novel intravenous regional anaesthetic technique for desensitization of hoof in cattle

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ABSTRACT

The cattle having hoof diseases were selected in the study and divided into 2 groups having 6 animals in each group. For induction of intravenous regional anesthesia, tourniquet was placed circumferentially at the metacarpus and just below dewclaw in group 1 and 2, respectively. Mixture of lignocaine and ketamine (L+K) (4 mg/kg and 3 mg/kg b. wt.) was injected in the radial vein in group 1 animals. However, in group 2 animals the dose of L+K was halved (2 mg/kg and 1.5 mg/kg b. wt.) and injected in the dorsal common digital vein III. The anesthetic potency was monitored by observing the HR, PR, RR, systolic pressure, diastolic pressure and SPO_2. In group 1 the heart rate decreased significantly at 10 min interval. Peripheral oxygen saturation significantly decreased up to 60 min and 40 minutes in group 1 and 2 animals, respectively. Systolic pressure significantly increased at 60 minute interval in group 1 animals. After removal of tourniquet, systolic pressure and diastolic pressure was significantly increased in group 2. Sensory and motor block onset time was less in group 2 as compared to group 1. Sensory and motor block recovery time was long in group 2 as compared to group 1 animals. It was concluded that novel IVRA technique was more safe as compared to standard IVRA for the hoof anesthesia in cattle because low doses of local anesthetic are required in this technique with early sensory and motor block, and prolonged effect.

Keywords: Bovine, Hoof diseases, IVRA, Ketamine, Lignocaine

Local and regional anesthesia techniques are the integral part of large animal surgery for economy and practical point of view. Hoof diseases are very common in dairy cattle, especially in poorly managed livestock farm (Thomas *et al.* 2016). Intravenous regional analgesia is relatively safe and economic technique for inducing anesthesia as well as bloodless short duration surgical procedures of extremities (Lumb and Jones 1984). This technique can be utilized for the management of cattle hoof diseases in field condition with minimum available facilities (Kumar *et al.* 2020). The disadvantages of IVRA encompass local anesthetic toxicity, poor muscle relaxation, tourniquet pain and minimal postoperative analgesia (Muhammad and Muhammad 2012). The ideal IVRA solution should have rapid onset, require less dose of local anesthetic, reduce tourniquet pain, and prolong post-deflation analgesia. This can be attained by adding certain adjuncts to local anesthetics (Kognole *et al*. 2004). In standard IVRA technique, the tourniquet is applied at the metatarsal or metacarpal region and large amount of local anesthetic is required, which sometimes may lead to local anesthetic toxicity during release of tourniquet (Skarda 1987, Weaver *et al.* 2005).

Ketamine is a general anesthetic but it also has local anesthetic qualities, which have been studied as a sole agent for IVRA (Lauretti *et al.* 1999). Ketamine antagonizes the spinal cord N-methyl D-aspartate (NMDA) glutamate receptors. These receptors affect analgesia through peripheral mechanisms, including inhibition of peripheral C fibre neurons (MacIver and Tanelian 1993). In addition to spinal cord, NMDA receptors have also been found on peripheral unmyelinated sensory axons. Ketamine is a potent analgesic agent that possesses both central and peripheral sites of action (Pedersen *et al.* 1998).

We utilized peripheral application of ketamine as an adjunct to lignocaine for IVRA. Further, to investigate the problem of local anaesthetic toxicity, dose of the local anesthetic was reduced using modified IVRA technique. No study till date has been undertaken on lower IVRA in bovines. Due to the paucity of literature on this aspect, the current study is designed to compare the efficacy of standard IVRA with modified IVRA using ketamine as an adjunct to lignocaine hydrochloride.

MATERIALS AND METHODS

The cattle having surgical conditions of hoof of forelimbs were included in the present study. The animals were

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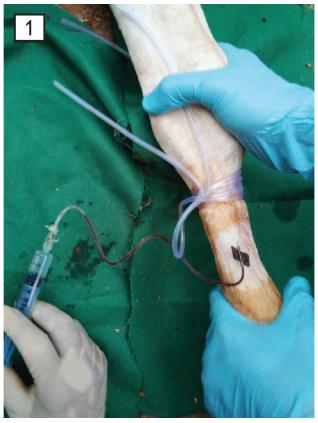

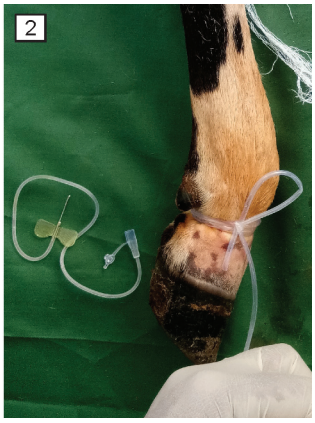

Figs 1–2. **1**. Tourniquet placement at metacarpus and placement of butterfly canula in the radial vein for induction of standard intravenous regional anesthesia (IVRA) in group 1 animals. **2**. Tourniquet placement just distal to dew claws for lower intravenous regional anesthesia (IVRA) in group 2 animals.

divided into 2 groups having 6 animals in each group. Intravenous regional anesthesia was induced as per the standard technique in group 1 animals (Yavari *et al.* 2017). However, in group 2 animals, tourniquet was applied just below the dew claws. The animals were prepared as per routine surgical procedure. The affected animals were off fed for 24 h. No premedication was given to any of the animal. Animals were casted and restrained in right lateral recumbency. The site was prepared aseptically and the area was painted with antiseptic solution. Briefly, in group 1 animal, tourniquet was placed circumferentially in the middle of the metacarpus (Fig. 1). Butterfly canula was placed in the radial vein and the area was exsanguinated. After exsanguination, mixture of lignocaine (4 mg/kg b. wt.) and ketamine (3 mg/kg b. wt.) was injected in the radial vein. In group 2 animals, after tourniquet placement just distal to dew claws (Fig. 2), butterfly canula was fixed in the dorsal common digital vein III and halved dose of lignocaine (2 mg/kg b.wt.) and ketamine (1.5 mg/kg b. wt.) was injected. After injection, the butterfly canula was removed and povidone iodine soaked cotton swab was applied over the injection site with moderate compression for 1–2 min to avoid unintended leakage of the injected drugs from the punctured vein or haematoma formation. In group 1 animals, the tourniquet was loosened for 10 to 15 sec and retightened for 2 to 3 min, and this procedure was repeated three times (Skarda 1987). However, in group 2 animals, tourniquet was released at once. The anesthetic potency of upper and lower intravenous regional anesthesia was monitored by monitoring the parameters given below.

Physiological parameters: Heart rate, pulse rate and respiration rate were recorded preoperatively (0), 5, 10, 15, 20, 30, 40, 50, 60 min or till the recovery and after removal of tourniquet.

Peripheral oxygen saturation (SPO_2): Peripheral oxygen saturation (SPO_2) is percentage of hemoglobin binding site occupied by oxygen in the blood circulation. It is measured by pulse oxymeter (Dr. Trust, Model no. DR50D, Nectar Life science Limited Works, Saidabad, Mohali, Punjab). The device was applied at the tip of the ear and the reading was taken preoperatively, 5, 10, 15, 20, 30, 40, 50, 60 min or till the recovery and after removal of tourniquet.

Systolic and diastolic pressure: Systolic and diastolic pressure was measured by non-invasive blood pressure monitoring unit (Romsons BPX automatic BP monitor) and is measured in mmHg. It was taken preoperatively, 5, 10, 15, 20, 30, 40, 50, 60 minutes or till the recovery and after removal of tourniquet.

Sensory and motor block onset time: Sensory block onset time is the time started from injection of drug to sensory block attained in all dermatomes. It was recorded preoperatively and up to 10 min as per method described by Kognole *et al.* (2004).

Sensory and motor block recovery time: It was measured after 30 min of administration of anesthesia at specific time intervals till the recovery after the administration of anesthesia as per method described by Kognole *et al.* (2004).

Complication: Any clinical sign of local anesthesia toxicity like methaemoglobinaemia, regurgitation, pain, bradycardia, tachycardia, hypotension and convulsion was vigilantly looked.

Statistical analysis: One way ANOVA (Analysis of variance) was used to compare the mean values at different intervals with their base values. Independent "t" test was used to compare the mean values between groups at different intervals.

RESULTS AND DISCUSSION

Hoof diseases such as interdigital fibroma/hyperplasia, sole ulcers, white line disease and inflammation of the adjacent soft tissues is very common in bovines specially in poorly managed farms (Cook *et al.* 2016). Such cases of hoof infections need surgical correction which require adequate pain management during intraoperative and postoperative period using local anaesthesia (LA) and analgesic agents (Janssen *et al.* 2016). In the present study the cases of interdigital fibroma/hyperplasia and sole ulcers were surgically treated under IVRA using mixture of lignocaine and ketamine (L+K). Short surgical procedures of the limbs and tail for an anticipated duration of 60 to 90 min can be best performed under IVRA or Bier's block (Brown *et al.* 1989). In the present study the animals were casted and restrained in right lateral recumbency because left lateral recumbency may affect the physiological parameters in ruminants and the results may be erratic. The dose of lignocaine and ketamine was halved in group 2 animals because the area to be desensitized was lesser in modified IVRA as compared to standard IVRA technique. Low dose of local anaesthesia and ketamine may also rule out the chances of complications and/or toxicity during release of tourniquet after completion of surgery. Toxicity during tourniquet removal is eluded if the tourniquet is loosened for 10 to 15 sec and retightened for 2 to 3 min, and this procedure is repeated three times (Skarda 1987). In the present study no complication was noted in modified

IVRA technique even after removal of tourniquet at once.

Mean±SE of heart rate, respiration rate, pulse rate (per minute), peripheral oxygen saturation (%), systolic pressure (mm of Hg) and diastolic pressure (mm of Hg) of animals of different groups at different time intervals is presented in Table 1. Heart rate increased significantly (P<0.05) in group 1 animals at 10 min. Thereafter, the heart rate was more or less similar to base value up to 60 min and again increased significantly (P<0.05) after removal of tourniquet. However, in group 2 animals heart rate was normal even after release of tourniquet. Significant (P<0.05) increase in heart rate in the animals of group 1 might be due to more tourniquet pain or restraining of animals in lateral recumbency. A significant (P< 0.05) increase in heart rate was also noted after IVRA (Yavari *et al.* 2017). Restraining of the animal induced stress response as indicated by an increased heart rate (Rizk *et al*. 2012). Significantly (P<0.05) increased heart rate after removal of tourniquet in group 1 animals may be due to sudden increase in the level of lignocaine and ketamine in circulation which may increase the heart rate.

No significant change in pulse rate was observed in any of the animals of different groups. It was within normal range up to end of the experiment and after removal of tourniquet. No significant change in pulse rate in group 1 and 2 might be due to analgesic effect of ketamine (Pedersen *et al.* 1998). In addition to spinal cord, NMDA receptors have also been identified on peripheral unmyelinated sensory axons. There was no significant change in respiration rate in both groups of animals. The IVRA tourniquet was released just after recovery from motor block and the animals were returned from lateral recumbency to standing position. However, Yavari *et al.* (2017) observed a significant decrease in respiration rate over time after removal of tourniquet from IVRA using 2% procaine.

Peripheral oxygen saturation (SPO_2) slightly increased at 5 min interval in group 1. Thereafter, the value decreased significantly (P<0.05) up to 60 min. However, the value was minimum at 30 min interval (78.00±1.26). In group 2, oxygen saturation was significantly low (P<0.05) between 15 and 40 min interval. Thereafter, the oxygen saturation increased towards the base value. Lateral recumbency affects the peripheral oxygen saturation in ruminants as rumen pressed the lungs and diaphragm. Lateral recumbency also affects the respiration in cattle leading to a moderate increase in arterial pCO_2 and a decrease in pO_2 (Yavari *et al*. 2017).

Systolic pressure significantly increased at 60 minutes in group 1 animals. It might be due to high dose of lignocaine hydrochloride for standard IVRA technique as

Table 1. Mean±SE of heart rate (per minute), pulse rate, respiration rate, peripheral oxygen saturation (%), systolic pressure (mm of Hg) and diastolic pressure (mm of Hg) of animals of different groups at different time intervals and just after removal of tourniquet (ART)

Parameter	Group	Time intervals (min)									
		0	5	10	15	20	30	40	50	60	ART
Heart rate	1	78 ±0.73^{a}	77 ±1.69	74 ±1.63*	75.33 ±1.33	78 ±1.15	78 ±.073	77.33 ±0.66^{ab}	76.33 ±0.61	77.66 ±0.66	82 ±1.52^{a}*
	2	74 ±0.73^{b}	74.33 ±0.95	74.33 ±0.80	75 ±1.43	75.66 ±0.02	75 ±1.84	75.66 ±1.20^{a}	75.33 ±0.66	74.33 ±1.40	75 ±1.43^{b}
Pulse rate	1	68.66 ±0.42	67.33 ±0.84^{a}	66.83 ±0.54^{a}	70 ±0.85	70.66 ±0.98^{a}	70.33 ±0.61	70 ±0.68	69 ±0.89	70.33 ±0.66	69.33 ±0.66
	2	71.33 ±0.66	72 ±0.51^{b}	72.66 ±0.66^{b}	72.33 ±0.61	69.66 ±0.61^{b}	72.33 ±0.61	72.33 ±1.20	74 ±1.03	73 ±0.51	71 ±0.85
Respiration rate	1	30 ±0.73^{a}	29.66 ±0.61^{a}	28.66 ±0.66	26.66 ±0.66	25.33 ±0.42	24.33 ±0.61	25 ±0.85	25 ±0.44^{a}	23.33 ±0.66^{a}	29.66 ±0.95^{a}
	2	25 ±0.85^{b}	26 ±0.51^{b}	28 ±1.03	27.33 ±0.98	26 ±1.03	26.33 ±1.08	26.66 ±0.66	27.66 ±0.95^{b}	28 ±1.15^{b}	24.33 ±0.61^{b}
Peripheral oxygen saturation (%)	1	92 ±0.73	93 ±0.36^{a}	90.33 ±0.55^{a}*	85.33 ±0.21^{a}*	81 ±0.96^{a}*	78 ±1.26*	83 ±0.63*	87 ±0.36*	88.33 ±0.55*	91 ±0.73
	2	93.33 ±0.84	79.33 ±8.01^{b}	75.66 ±6.85^{b}	75.66 ±4.98^{b}*	74.33 ±3.60^{b}*	80 ±2.63*	81.33 ±3.65*	86 ±2.52	85.66 ±3.39	92.33 ±0.40
Systolic pressure (mm of Hg)	1	123 ±0.85	123.33 ±0.66	123.66 ±0.42	124.33 ±0.61	125 ±0.68	123.66 ±0.61	123 ±0.85	124 ±0.73	126.33 ±0.63*	128 ±0.44*
	2	124 ±1.86	124.33 ±0.61	124.33 ±0.61	125 ±0.44	124.66 ±0.42	122.66 ±0.66	124 ±0.73	125.33 ±0.42	125 ±0.44	125 ±0.44
Diastolic pressure (mm of Hg)	1	95.33 ±0.84	95.66 ±0.61	95.66 ±0.95	94.66 ±1.11	94 ±0.73^{a}	95 ±0.61	94.33 ±0.61	94.66 ±0.84	96 ±0.73	98 ±0.73*
	2	94.33 ±0.61	94.66 ±0.42	94 ±0.73	94.33 ±0.80	96.33 ±0.33^{b}	95.33 ±0.44	95 ±0.44	94.33 ±0.61	93.66 ±0.61	95.33 ±0.44

*Differ significantly (P<0.05) from day 0 values. ^{ab}Value with different alphabets differ significantly (P < 0.05) between groups at particular time interval.

Table 2. Mean±SE of sensory block onset time (SBOT), sensory block recovery time (SBRT), motor block onset time (MBOT) and motor block recovery time (MBRT) (in min) of animals of different groups

Group	Sensory block onset time (SBOT)	Sensory block recovery time (SBRT)	Motor block onset time (MBOT)	Motor block recovery time (MBRT)
1	3.50±.0.22[b]	64.20±1.05	4.50±0.42	68.16±1.19
2	3.33±0.33[a]	65.00±1.96	4.16±0.22	69.16±0.98

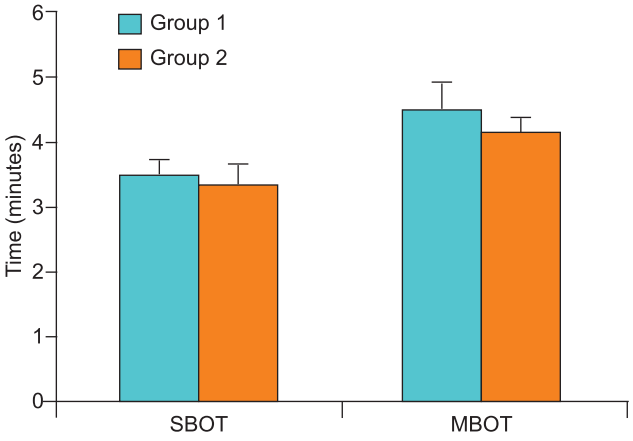

Fig. 3. Mean±SE of sensory block onset time (SBOT) and motor block onset time (MBOT) after administration of Lignocaine hydrochloride and Ketamine hydrochloride in the animals of different groups.

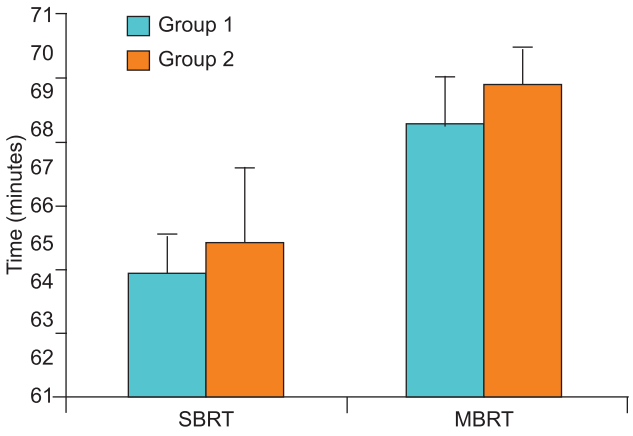

Fig. 4. Mean±SE of sensory block recovery time (SBRT) and motor block recovery time (MBRT) after administration of lignocaine hydrochloride and Ketamine hydrochloride in the animals of different groups.

compared to the dose administered in group 2 animals. A significant increase in mean arterial pressure (MAP) was also recorded after IVRA (Yavari *et al.* 2017). There was no significant change in systolic pressure in group 2 animals. After removal of the tourniquet, significant increase in systolic pressure was observed in group 1 animals which may be due to increase in the level of ketamine in circulation.

Diastolic pressure slightly decreased in group 1, at 20 min interval but the decrease was non-significant. However, the diastolic pressure was more or less similar to base value in group 2. No patient of the either group needed treatment for hypotension or bradycardia. The significantly higher mean arterial pressure (MAP) in the IVRA cows may indicate a stress response caused by tourniquet pain (Yavari *et al.* 2017). The results of present study indicated no tourniquet pain in the animals of both group. No significant change in blood pressure was observed after using lidocaine and its combination with ketamine as an IVRA in human beings (Haider and Mahdi 2013). After removal of the tourniquet, significant increase in diastolic pressure in group 1 might be due to increase in the level of ketamine in circulation which may increase the systolic pressure.

Sensory and motor block was measured by pin prick to the interdigital space. It is a common nociceptive test for investigation of desensitization of surgical site after induction of local anaesthesia and it is suggested that this test should be reconsidered before surgical interventions (Hudson *et al.* 2008). Sensory block onset time was significantly ($P<0.05$) lower in group 2 as compared to group 1 animals. Hala *et al.* (2014) also found that the use of 0.3% ketamine for regional anesthesia of upper extremities is adequate for complete sympathetic, sensory and motor block. Kognole *et al.* (2004) observed less mean time (1.53±0.33 min) required for the onset of anesthesia when bupivacaine HCl and ketamine HCl combination was used as IVRA. There was early onset of sensory block after IVRA using lignocaine + ketamine (Viscomi *et al.* 2009).

Motor block onset time (MBOT) was also lesser in group 2 as compared to group 1. Mir *et al.* (2007) also observed a rapid onset of MBOT when 1% ketamine was added to lidocaine. Ketamine decreased the block beginning time, delay in tourniquet pain, and reduced the need for analgesics after surgery (Kumar *et al.* 2012). Improved intraoperative conditions with rapid onset of motor blocks in group 2 animals may also be associated with less pain during surgery when ketamine was added to lignocaine. Hala *et al.* (2014) found that the use of 0.3% ketamine for regional anesthesia of upper extremities is adequate for complete sympathetic and motor block.

There was no significant ($P>0.05$) change in sensory and motor block recovery time between group 1 and 2. However, SBRT was slightly less in group 1 as compared to group 2 animals. Sensory block recovery time was prolonged in the lignocaine combined with ketamine as compared to lignocaine alone (Elmetwaly *et al.* 2010). When ketamine is used with lignocaine (0.5%) in a dose of 3 mg/kg of body weight, duration of analgesia after release of tourniquet is longer, and the quality of analgesia is superior (Sheth *et al.* 2016). Motor block recovery time was also more in group 2 as compared to group 1 animals. Motor block recovery time was prolonged in the lignocaine combined with ketamine as compared to lignocaine alone (Elmetwaly *et al.* 2010).

Release of the tourniquet did not show any sign of

cardiovascular or CNS toxicity in both groups of animals. However, the animals of group 1 were in prostration for 5–6 min after release of tourniquet. As the animal returned from lateral recumbency to standing position, slight stumbling was noted in both groups of animals.

On the basis of results, it was concluded that novel intravenous regional anaesthesia technique was safer as compared to standard IVRA technique because low doses of local anesthetic are required in this technique with early sensory and motor block, and prolonged effect. The results of the present study also suggested that tourniquet may be removed at once in novel IVRA technique without any local anesthetic complications due to sudden entrance of local anesthetic and ketamine in circulation.

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