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Evaluation of Tramadol, Pentazocine Lactate and Meloxicam as Pre-emptive Analgesics for Pain Management in Canine Ovariohysterectomy

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ABSTRACT

Background: It is usually accepted that some degree of post-surgical pain will be commonly present. There are different pain scales adopted in veterinary practice to assess these behavioural signs to measure pain. VAS had been used in human medicine for many years to measure pain and was found equally satisfactory in dogs. Pre-emptive analgesia (PEA) is grasping popularity in recent days, the concept of which originated during the time of growing appreciation of dynamic characteristics of pain pathway for obtaining effective analgesia prior to the surgical trauma.

Methods: The present study was conducted to evaluate the effects of tramadol, pentazocine lactate and meloxicam as pre-emptive analgesics in dogs premedicated with glycopyrrolate, induction and maintenance with propofol continuous rate infusion (CRI) for certain clinical and physiological parameters. The animals were randomly divided into three equal groups *viz*. Group-T, Group-P and Group-M comprising six animals in each group and all were premedicated with glycopyrrolate, I/M. After 10 minutes of pre-anaesthetic administration, pre-emptive analgesia was given (Tramadol in Group-T, Pentazocine lactate in Group-P and Meloxicam in Group-M intravenously). After 10 minutes of pre-emptive analgesic administration, induction was achieved with propofol I/V and also maintained by CRI method up to 1 hour. Clinical and physiological parameters were recorded at 0 (baseline) minute before premedication, thereafter at 10 min, 30 min, 1 hr, 2 hr and 3 hr after pre-emptive analgesic administration.

Result: There was no sedation observed within 10 min following pre-emptive analgesia and quality of sedation was recorded as score-0 in all the groups. Time for induction was significantly higher in group-M as compared to group-T and P. Quality of induction in all the groups ranged from score-0 to score1, assessment of peri-operative analgesia was recorded as score-0 in group-T and group-P, whereas in group-M it ranged from score-0 to score-1. Depth of anaesthesia was recorded as score-0 to score-1 in all the groups and quality of recovery was recorded as score-0 to score-1 in group-T and group-P and score-1 to score-2 in group-M. Assessment of post-operative analgesia by VAS was significantly lower in group-T as compared to group-P and M. In all the three groups, the heart rate increased significantly at 30 min interval and thereafter it decreased significantly till the end of the study. Respiratory rate also decreased significantly till 1 hr and thereafter it gradually increased till the end of study in all the groups. Rectal temperature, SpO_2, systolic pressure and diastolic pressure decreased significantly at 30 min and thereafter increased gradually and approached base values in all the groups.

Key words: Continuous rate infusion (CRI), Glycopyrrolate, Meloxicam, Pentazocine lactate, Pre-emptive analgesics, Propofol, Tramadol.

INTRODUCTION

All the surgical procedures, including ovariohysterectomy cause pain. There are different pain scales adopted in veterinary practice to assess these behavioral signs to measure pain. VAS had been used in human medicine for many years to measure pain and was found equally satisfactory in dogs (Reid and Nolan, 1991). Pre-emptive analgesia (PEA) is grasping popularity in recent days, it is the concept which originated during the time of growing appreciation of dynamic characteristics of pain pathway, for obtaining effective analgesia prior to the surgical trauma (Kotur, 2006). Tramadol is a centrally acting synthetic 4-phenyl-piperidine analogue of codeine and has been used as a successful post-operative analgesic (Monteiro *et al.,* 2009).

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Pentazocine is a narcotic analgesic with mixed agonist and antagonist activity. Effective analgesia occurs within 15 to 20 minutes after intramuscular (IM) injection in dogs (Weber, 2015). Meloxicam, a NSAID of the oxicam group, is a potent inhibitor of prostaglandin (PG) synthesis that has anti-inflammatory, analgesic and antipyretic properties. Meloxicam is a potent analgesic in abdominal surgical procedures of dogs and cats (Mathews *et al*., 2001; Slingsby and Waterman-Pearson, 2000). Propofol is an injectable anaesthetic agent belonging to the alkyl phenol group and can be used for both induction and maintenance of anaesthesia and it is most suitable for total intravenous anaesthesia (TIVA) (Adetunji *et al.,* 2002). The study was undertaken to compare the efficacy of pre-emptive analgesia with Tramadol, Pentazocine lactate and Meloxicam in bitches undergoing ovariohysterectomy based on clinical and physiological parameters.

MATERIALS AND METHODS

The trial was conducted at Department of Veterinary Surgery and Radiology, College of Veterinary Sciences and Animal Husbandry, Central Agricultural University, Mizoram, India in the year 2019-2020 and was approved by the Institutional Animal Ethics Committee.

Experimental animals and preparation

The study was conducted in 18 clinical cases of dogs brought for ovariohysterectomy aged 1-4 years with body weight ranging from 9-15 kg. All Animals were fasted overnight with food and water withheld for 12 and 6 hours, respectively prior to the anaesthetic trial. Animals were examined for all the vital physiological parameters before any medication on the day of surgery.

Experimental design

The animals were randomly divided into three equal groups *viz.* Group-T, Group-P and Group-M comprising six animals in each group and all were premedicated with glycopyrrolate @ 0.01 mg/kg body weight, IM. After 10 minutes of pre-anaesthetic administration, pre-emptive analgesia was given (Tramadol @ 2 mg/kg, body weight, IV in Group-T, Pentazocine lactate @ 2 mg/kg, body weight, IV in Group-P and Meloxicam @ 0.2 mg/kg, body weight, IV in Group-M). After 10 minutes of pre-emptive analgesic administration, induction was achieved with propofol @ 5 mg/kg body weight, IV and maintained using propofol @ 25 mg/kg/hr, IV by CRI method up to 1 hour.

Clinical parameters

Time for sedation

Observed up to 10 min after pre-emptive analgesic administration.

Quality of sedation

Sedation scoring was done according to the method described by Amengual *et al.,* 2013.

Time for induction

Time in seconds from administration of the induction agent to till the animal loses its reflexes.

Quality of induction

The overall quality of anaesthetic induction was scored as per the method described by Amengual *et al.,* 2013.

Assessment of peri-operative analgesia

The quality of analgesia was assessed on the inter-digital space of hind foot as per the method described by Amengual *et al.,* 2013.

Depth of anaesthesia

Anaesthetic depth was assessed as per the method described by Ahmad *et al*., 2013.

Quality of recovery

Quality of recovery was assessed as per the method described by Sams *et al*., 2008.

Assessment of post-operative analgesia

Visual analogue scale (VAS) was used to assess post-operative analgesia at 1 hr, 2 hr and 3 hr interval with 0 representing no pain and 10 representing excruciating pain, according to the previous description (Mathews, 1996).

Physiological observations

Heart rate (beats/minute), respiration rate (breaths/minute), rectal temperature (°C), peripheral arterial oxygen saturation (SpO_2), systolic pressure and diastolic pressure were recorded at 0 minute before premedication thereafter 10 min, 30 min, 1 hr, 2 hr and 3 hr after analgesic administration.

Statistical analysis was carried out by Statistical Package for the Social Sciences (SPSS) version 20.0. One way analysis of variance (ANOVA) was used for comparing different groups at different time intervals and paired sample t-test was used to compare different time intervals in the same group. Results were presented as mean±standard deviation (mean±SD) and differences were considered statistically significant when $P<0.05$.

RESULTS AND DISCUSSION

Clinical parameters

Time for sedation

The mean±SD values of time for sedation for all the three groups were recorded and depicted in the Table 1.

The differences in sedation time among all the groups-T, P and M were statistically non-significant ($P>0.05$). The animals in all the groups did not show any sedation within the time period after pre-emptive analgesia to induction of anaesthesia (within 10 min). The time for sedation of animals in all the with groups-T, P and M was not recorded since there was no sedation. Many conflicting evidences are there with respect to sedative effect of tramadol in dogs. In one report, a dose-dependent sedative effect was noticed in dogs

administered with tramadol (1, 2, or 4 mg/kg body weight, IV) (McMillan *et al.,* 2008). The inefficacy of opioids in enhancing the degree of sedation in dogs may be related to its pharmacokinetic and pharmacodynamic characteristics (Monteiro *et al.,* 2016).

Quality of sedation

The mean±SD values of Quality for sedation for all the three groups were recorded and depicted in the Table 1.

The differences in quality of sedation among groups-T, P and M were statistically non-significant (P>0.05). The animals in all the groups did not show any sedation within the time period after pre-emptive analgesia to induction of anaesthesia (within 10 min). The scoring of quality of sedation in animals with groups-T, P and M were recorded as 0.00±0.00 (score 0).

Time for induction

The mean±SD values of time for induction for all the three groups were recorded and depicted in the Table 1 and Fig 1.

The time for induction was significantly (P<0.05) higher in group-M as compared to group-T and -P. Non-significant (P>0.05) difference was noticed between groups-T and P. The time for induction of animals with propofol in group-T, P and M were recorded as 43.50±7.19, 48.67±4.27 and 57.83±9.60 seconds, respectively. Animals of group-T showed lowest induction time (43.50±7.19 seconds), whereas animals of group-P took a bit longer period for induction (48.67±4.27 seconds) and animals of group-M showed highest induction time (57.83±9.60 seconds).

Quality of induction

The mean±SD values of Quality for induction for all the three groups were recorded and depicted in the Table 1 and Fig 1.

The differences in quality of induction among all the three groups were statistically non-significant (P>0.05). The scoring of quality of induction of animals with propofol in groups-T, P and M were recorded as 0.17±0.40, 0.50±0.54 and 0.83±0.40, respectively. Animals in all the three groups showed smooth transition with no paddling (score 0) to occasional, slow paddling (score 1) movements while induction stage. Lower induction time noticed in group-T and group-P might be due to synergistic effect of opioids and propofol (Anandmay *et al.,* 2016).

Assessment of peri-operative analgesia

The mean±SD values of assessment of peri-operative analgesia for all the three groups were recorded and depicted in Table 1 and Fig 1.

The differences in peri-operative analgesia among all the three groups were statistically non-significant (P>0.05). The peri-operative analgesia in the animals of groups-T, P and M did not differ significantly (P>0.05) and the scores recorded were 0.00±0.00, 0.00±0.00 and 0.17±0.40, respectively. Group-T and group-P animals showed no peri-operative pain (score 0) and group-M animals showed no pain to little pain (range: score 0 to score 1). Pain caused due to intravenous administration of propofol can be reduced by administration of opioids (Branson, 2007). Tramadol has been categorized as an opioid analgesic although it can provide analgesia by both opioid and non-opioid mechanisms (Mastrocinque and Fantoni, 2003). It is probable that NSAIDs do not provide any surgical analgesia (Pyati and Gan, 2007).

Depth of anaesthesia

The mean±SD values of depth of anaesthesia for all three groups were recorded and depicted in Table 1 and Fig 1.

The differences in depth of anaesthesia among all the three groups were statistically non-significant (P>0.05). The depth of anaesthesia in the animals of group-T, P and M did not differ significantly (P>0.05) and the scores were recorded as 1.50±0.54, 1.33±0.51 and 1.50±0.54, respectively. Animals in all the three groups showed intact but weak (score 1) to very weak (score 2) palpebral reflex during anaesthesia. Occasional response of palpebral reflex might be due to pain during surgical procedure. In a previous study, mild palpebral

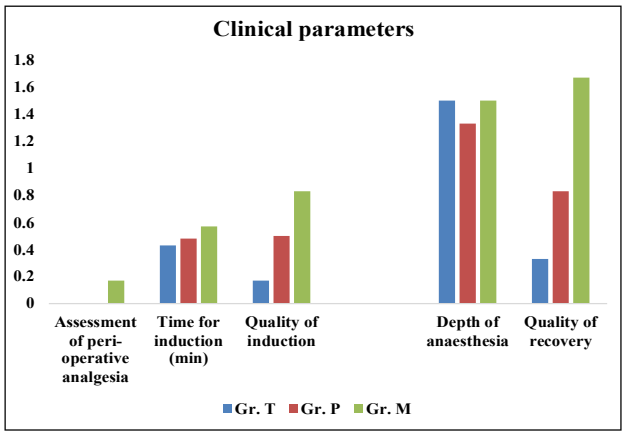

Fig 1: Clinical parameters in group T, P and M.

Table 1: Mean±SD values of clinical parameters in group T, P and M.

Parameter	Group-T	Group-P	Group-M
Time for sedation (up to 10 min)	Not sedated	Not sedated	Not sedated
Quality of sedation	0.00±0.00^{A}	0.00±0.00^{A}	0.00±0.00^{A}
Time for induction (sec)	43.50±7.19^{A}	48.67±4.27^{A}	57.83±9.60^{B}
Quality of induction	0.17±0.40^{A}	0.50±0.54^{A}	0.83±0.40^{A}
Assessment of peri-operative analgesia	0.00±0.00^{A}	0.00±0.00^{A}	0.17±0.40^{A}
Depth of anaesthesia	1.50±0.54^{A}	1.33±0.51^{A}	1.50±0.54^{A}
Quality of recovery	0.33±0.51^{A}	0.83±0.40^{A}	1.67±0.51^{B}

Superscripts A and B between the groups differ significantly (P<0.05).

reflexes were observed in dogs pre-medicated with pentazocine in propofol anaesthesia (Chandrashekarappa and Ananda, 2009).

Quality of recovery

The mean±SD values of quality of recovery for all the three groups were recorded and depicted in Table 1 and Fig 1.

The scoring of quality of recovery was significantly (P<0.05) higher in group-M as compared to group-T and P. Non-significant (P>0.05) difference was noticed between group-T and P. The scoring of quality of recovery in group-T, P and M animals were recorded as 0.33±0.51, 0.83±0.40 and 1.67±0.51, respectively. Animals in group-T and P showed smooth uncomplicated recovery (score 0) to uncomplicated recovery (score 1) whereas animals in group-M showed uncomplicated recovery (score 1) to difficult recovery (score 2). Combination of IV anaesthetic with opioid analgesics have been used for achieving balanced anaesthesia with reduced side effects and promote earlier recovery time (Wu *et al.,* 2014). Uncomplicated recovery without any complications was observed in all the three groups. Similar findings were also observed by, Sams *et al.* (2008), Thejasree *et al.* (2017) and Shinde *et al.* (2018) in propofol anaesthesia.

Assessment of post-operative analgesia

The mean±SD values of VAS for all the three groups were recorded and depicted in Table 2 and Fig 2.

Table 2: Mean±SD values of Visual Analog Scale (VAS) at different time interval in group T, P and M.

VAS	1 hr	2 hr	3 hr
Group-T	3.33 ± 0.81^{Aa}	2.17 ± 0.75^{Ab}	0.33 ± 0.51^{Ac}
Group-P	4.83 ± 0.40^{Ba}	2.83 ± 0.40^{Ab}	1.33 ± 0.81^{Bc}
Group-M	4.83 ± 0.40^{Ba}	3.50 ± 0.54^{Bb}	2.33 ± 0.51^{Cc}

Superscripts A, B and C between the groups and superscripts a, b and c between the time intervals within a group differ significantly (P<0.05).

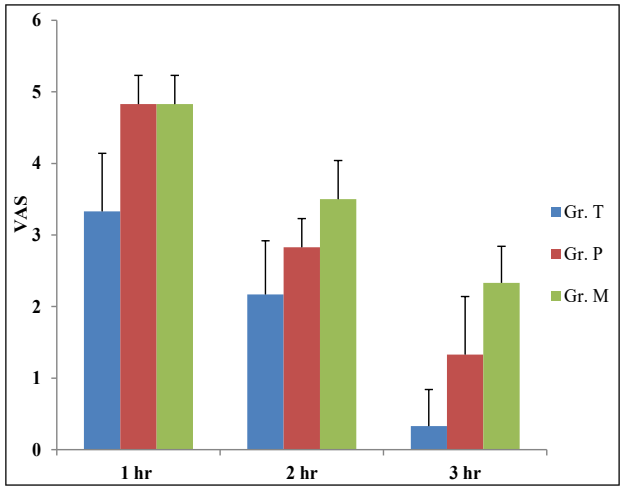

Fig 2: Visual Analog Scale (VAS) at different time intervals in group T, P and M.

The VAS was significantly (P<0.05) higher in group-P and M as compared to group-T at 1 hr interval after analgesia. The VAS was significantly (P<0.05) higher in group-M as compared to group-T and group-P at 2 hr interval after analgesia. At 3 hr interval after analgesia, the VAS was significantly (P<0.05) lower in group-T as compared to group-P and M. There was significant (P<0.05) decrease in VAS at different time intervals (1 hr, 2 hr and 3 hr) in all the three groups. At 3 hr interval after analgesia, group-T recorded least VAS (0.33±0.51) followed by group P (1.33±0.81) and group M (2.33±0.51). Tramadol has been categorized as an opioid analgesic although it can provide analgesia by both opioid and non-opioid mechanisms and has been shown to provide sufficient post-operative analgesia in dogs undergoing ovariohysterectomy (Mastrocinque and Fantoni, 2003). Tramadol provided sufficient post-operative analgesia without any side effects in dogs undergoing maxillectomy or mandibulectomy (Martins *et al.,* 2010). NSAIDs are not effective in acute pain and are thus ineffective (though useful later) are inadequate for immediate post-operative analgesia. It is probable that NSAIDs do not provide any surgical analgesia (Pyati and Gan, 2007).

Physiological parameters

Heart rate (beats/minute)

The mean±SD values of heart rate (beats/min) of different groups at different time intervals were recorded and depicted in the Table 3 and Fig 3.

There was non-significant (P>0.05) difference noticed in the mean values of heart rate between different groups at various time intervals throughout the study period. The heart rate differed non-significantly (P>0.05) at 10 min after analgesia in all the groups as compared to 0 min (baseline) value and at 30 min post analgesia there was significant (P<0.05) increase and thereafter it decreased significantly (P<0.05) till the end of the study. Heart rate increased after the administration of glycopyrrolate in all three groups as it causes increase in heart rate as also opined by Dyson and Davies (1999). Tachycardia noticed in group-T animals could be attributed to vagolytic effect of anticolinergic drug and lack of cardiac depression effect of tramadol as reported by Natalini *et al.* (2007) and Borges *et al.* (2008). In group-P and -M tachycardia effect could be due to anticolinergic drug as reported by Pandey and Sharma (1986) and Amarpal *et al.* (1996).

Respiration rate (breaths/minute)

The mean±SD values of respiratory rate (breaths/min) of different groups at different time intervals were recorded and depicted in the Table 3 and Fig 4.

There was non-significant (P>0.05) difference noticed in the mean values of respiratory rate between different groups at different time intervals throughout the study period. The respiratory rate decreased significantly (P<0.05) from 0 min to 1 hr after analgesia in group-T and P. In group-M, there was non-significant (P>0.05) difference noticed between 0 min to 10 min after analgesia, thereafter it

Table 3: Mean±SD values of physiological parameters at different time interval in group T, P and M.

Parameter	Group	0 min	10 min	30 min	1 hr	2 hr	3 hr
Heart rate	T	95.83 ± 1.83^{Aa}	97.33 ± 1.96^{Aa}	127.17 ± 3.76^{Ab}	121.67 ± 2.73^{Ac}	112.50 ± 3.33^{Ad}	105.00 ± 3.57^{Ae}
	P	98.17 ± 5.07^{Aa}	99.33 ± 5.31^{Aa}	127.83 ± 4.21^{Ab}	121.50 ± 3.45^{Ac}	114.83 ± 4.16^{Ad}	104.83 ± 3.92^{Ae}
	M	97.00 ± 2.36^{Aa}	97.67 ± 2.33^{Aa}	123.67 ± 8.59^{Ab}	119.50 ± 6.92^{Ac}	112.83 ± 5.23^{Ad}	107.33 ± 4.96^{Ae}
Respiratory rate	T	33.00 ± 0.25^{Aa}	31.33 ± 0.23^{Ab}	29.83 ± 0.46^{Ac}	27.17 ± 0.26^{Ad}	30.00 ± 0.31^{Abc}	31.50 ± 0.57^{Aab}
	P	34.17 ± 0.45^{Aa}	31.75 ± 0.41^{Ab}	29.00 ± 0.51^{Ac}	27.33 ± 0.45^{Ad}	29.33 ± 0.37^{Ac}	30.67 ± 0.64^{Abc}
	M	32.67 ± 0.34^{Aa}	32.33 ± 0.55^{Aa}	29.67 ± 0.33^{Ab}	27.00 ± 0.42^{Ac}	30.17 ± 0.26^{Ab}	31.50 ± 0.59^{Aab}
Rectal temperature	T	38.51 ± 0.22^{Aa}	38.33 ± 0.15^{Aa}	36.83 ± 0.55^{Ab}	36.90 ± 0.58^{Ab}	37.75 ± 0.70^{Aab}	38.46 ± 0.32^{Aa}
	P	38.49 ± 0.20^{Aa}	38.41 ± 0.57^{Aa}	36.36 ± 0.63^{Ab}	36.56 ± 0.70^{Ab}	37.80 ± 0.31^{Aab}	38.32 ± 0.33^{Aa}
	M	38.41 ± 0.24^{Aa}	38.35 ± 0.44^{Aa}	36.15 ± 0.50^{Ab}	36.65 ± 0.59^{Ab}	37.86 ± 0.40^{Aab}	38.38 ± 0.29^{Aa}
SpO_2	T	97.17 ± 0.75^{Aa}	96.98 ± 0.58^{Aa}	93.50 ± 0.56^{Ab}	92.83 ± 0.78^{Ab}	94.80 ± 0.59^{Aab}	96.17 ± 0.75^{Aa}
	P	97.00 ± 0.63^{Aa}	97.05 ± 0.49^{Aa}	93.50 ± 0.37^{Ab}	91.83 ± 0.65^{Ab}	95.01 ± 0.62^{Aab}	96.50 ± 0.56^{Aa}
	M	97.33 ± 0.57^{Aa}	97.25 ± 0.67^{Aa}	92.83 ± 0.45^{Ab}	92.00 ± 0.63^{Ab}	94.17 ± 0.72^{Aab}	96.00 ± 0.63^{Aa}
Systolic pressure	T	120.67 ± 3.07^{Aa}	119.17 ± 2.92^{Aa}	115.83 ± 2.48^{Ab}	117.33 ± 2.33^{Aab}	119.17 ± 0.75^{Aa}	120.73 ± 1.03^{Aa}
	P	119.67 ± 2.06^{Aa}	118.83 ± 1.32^{Aa}	114.17 ± 2.13^{Ab}	116.80 ± 2.88^{Aab}	119.67 ± 2.94^{Aa}	121.00 ± 1.54^{Aa}
	M	119.17 ± 1.32^{Aa}	119.67 ± 1.63^{Aa}	115.27 ± 0.51^{Ab}	117.35 ± 1.21^{Aab}	118.67 ± 0.51^{Aa}	119.83 ± 0.75^{Aa}
Diastolic pressure	T	79.00 ± 0.78^{Aa}	78.00 ± 0.89^{Aa}	74.33 ± 0.81^{Ab}	76.15 ± 0.73^{Aab}	78.75 ± 0.83^{Aa}	79.33 ± 0.93^{Aa}
	P	78.67 ± 0.69^{Aa}	79.01 ± 0.56^{Aa}	75.83 ± 0.75^{Ab}	77.83 ± 0.76^{Aab}	78.98 ± 0.98^{Aa}	79.17 ± 0.86^{Aa}
	M	80.00 ± 0.63^{Aa}	78.67 ± 0.81^{Aa}	75.05 ± 0.51^{Ab}	77.02 ± 0.69^{Aab}	79.33 ± 0.77^{Aa}	80.23 ± 0.89^{Aa}

Superscripts A and B between the groups and superscripts a, b, c, d and e between the time intervals within a group differ significantly ($P<0.05$).

significantly (P<0.05) decreased up to 1 hr after analgesia. Significant (P<0.05) increase in respiratory rate was noticed from 1 hr till the end of the study in all the three groups. The decrease in respiratory rate could be due to depression of respiratory center by propofol. Similar finding of significant (P<0.05) decrease in the respiratory rate followed by increase in respiratory rate of dogs in propofol anaesthesia was observed by Thejasree *et al.* (2018) and Saikia *et al.* (2019). The decrease in respiratory rate following tramadol administration was also observed by Mondal *et al.* (2006), McMillan *et al.* (2008) and Gupta *et al.* (2009). The decline in respiratory rate following pentazocine lactate administration was also recorded by Amarpal *et al.* (1996) and Chandrashekarappa *et al.* (2009) and following meloxicam administration by Laredo *et al.* (2004). Early significant (P<0.05) decrease in the respiratory rate noticed in group-T and P as compared to group-M could be due to the depressing effect of opioids (tramadol and pentazocine lactate) on respiratory center.

Rectal temperature (°C)

The mean±SD values of rectal temperature (°C) of different groups at different time intervals were recorded and depicted in the Table 3 and Fig 5.

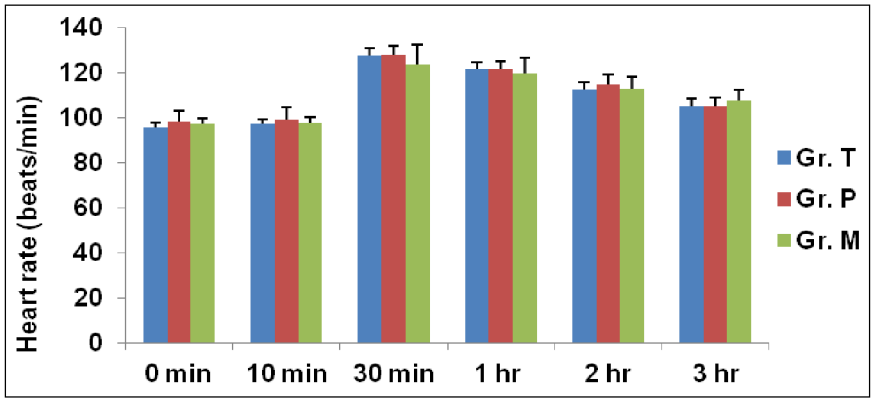

Fig 3: Heart rate at different time intervals in group T, P and M.

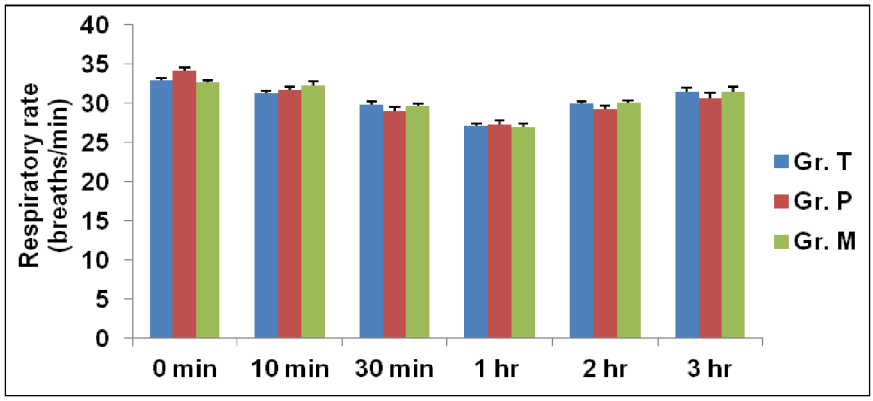

Fig 4: Respiratory rate at different time intervals in group T, P and M.

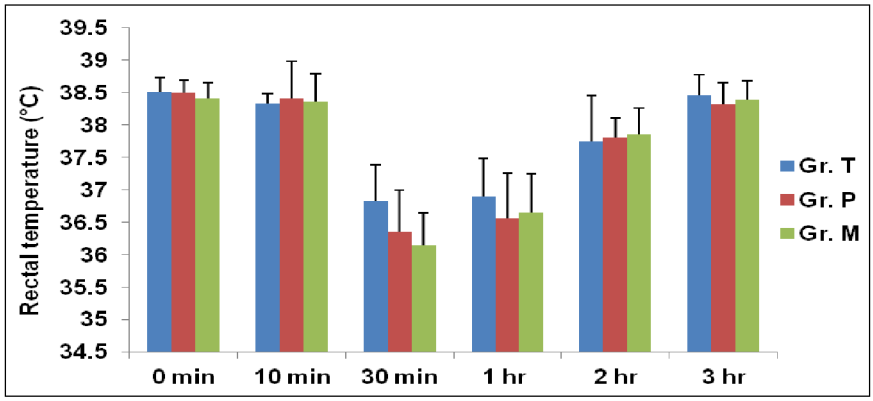

Fig 5: Rectal temperature (°C) at different time intervals in group T, P and M.

There was non-significant (P>0.05) difference noticed in the mean values of rectal temperature between different groups at various time intervals throughout the study period. The rectal temperature decreased significantly (P<0.05) at 30 min after analgesia in all the three groups. At 3 hr after analgesia, there was significant (P<0.05) increase in rectal temperature noticed in all the three groups as compared to 30 min value. In general anaesthesia, there is hypothermia because of generalized distribution of blood as a result of peripheral vasodilation, reduced activity of reticular activating system, depression of thermoregulatory center, decreased metabolic rate and reduced skeletal muscle activity (Sahoo, 2015). Similar finding of significant (P<0.05) decrease in rectal temperature after propofol administration was observed by Thejasree *et al.* (2018). However non-significant (P>0.05) decrease was observed by Shinde *et al.* (2018) and Saikia *et al.* (2019) in propofol anaesthesia. At 3 hr after analgesia, there was significant (P<0.05) increase in rectal temperature noticed in all the three groups as compared to 30 min value which might be due to withdrawal effects of general anaesthesia.

Peripheral arterial oxygen saturation (SpO_2), (%)

The mean±SD values of SpO_2 (%) of different groups at different time intervals were recorded and depicted in the Table 3 and Fig 6.

There was non-significant (P>0.05) difference noticed in the mean values of SpO_2 between different groups at various time intervals throughout the study period. The SpO_2 decreased significantly (P<0.05) at 30 min after analgesia in all the three groups. At 3 hr after analgesia, there was significant (P<0.05) increase in SpO_2 noticed in all the three groups as compared to 30 min value. Greater degree of respiratory depression might be the reason of higher decrease in SpO_2 values and the values remained within the normal physiological range *i.e.*, 90 to 100 in the present study. At 3 hr after analgesia, there was significant (P<0.05) increase in SpO_2 noticed in all the three groups as compared to 30 min value. Similar findings of significant decrease in SpO_2 after propofol administration was observed by Thejasree *et al.* (2018) and Saikia *et al.* (2019).

Blood pressure (mmHg)

Systolic pressure

The mean±SD values of systolic pressure (mmHg) of different groups at different time intervals were recorded and depicted in the Table 3 and Fig 7.

There was non-significant (P>0.05) difference noticed in the mean values of systolic pressure between different groups at various time intervals throughout the study period. The systolic pressure decreased significantly (P<0.05) at 30 min after analgesia as compared to 0 min (baseline) value

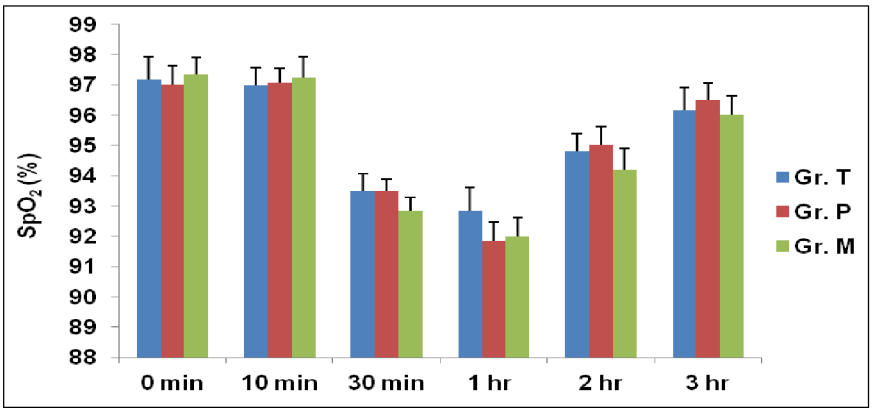

Fig 6: SpO_2 (%) at different time intervals in group T, P and M.

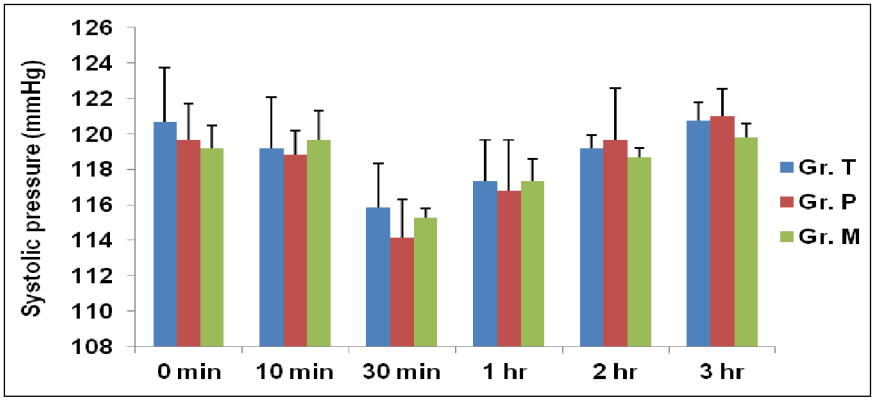

Fig 7: Systolic pressure (mmHg) at different time intervals in group T, P and M.

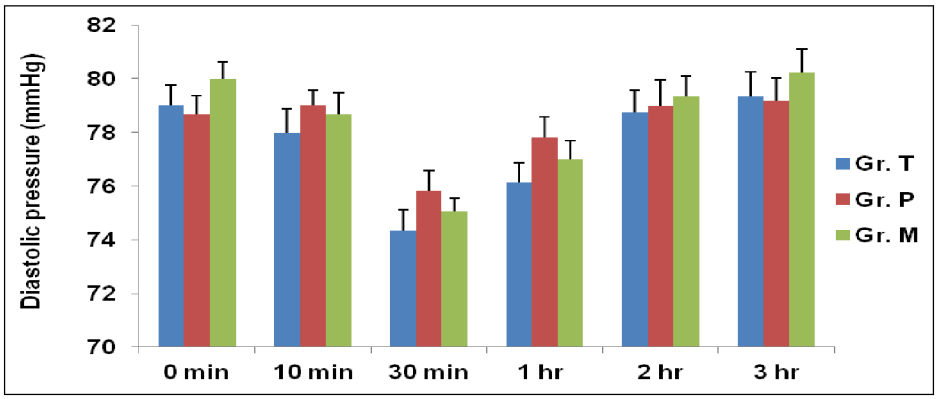

Fig 8: Diastolic pressure (mmHg) at different time intervals in group T, P and M.

in all the three groups and thereafter it increased gradually till the end of the study. Decrease in systolic pressure after propofol administration could be attributed to peripheral vasodilation, decreased sympathetic outflow and myocardial depression. Propofol induced decrease in systemic arterial blood pressure might be due to its direct negative inotropic action and decrease of arterial and venous vascular tone. Similar finding was also observed by Sams *et al.* (2008), Amengual *et al.* (2013) and Saikia *et al.* (2019) with propofol anaesthesia.

Diastolic pressure

The mean±SD values of diastolic pressure (mmHg) of different groups at different time intervals were recorded and depicted in the Table 3 and Fig 8.

There was non-significant (P>0.05) difference noticed in the mean values of diastolic pressure between different groups at various time intervals throughout the study period. The diastolic pressure decreased significantly (P<0.05) at 30 min after analgesia as compared to 0 min (baseline) value in all the three groups and thereafter it increased gradually till the end of the study. Decrease in diastolic pressure after propofol administration might have resulted due to peripheral vasodilation, decreased sympathetic outflow and myocardial depression. Decrease in diastolic pressure with propofol induction has also been reported by Amengual *et al.* (2013), Taboada and Leece (2014) and Saikia *et al.* (2019).

CONCLUSION

Based on the above findings, it is concluded that induction time was less, quality of induction was good and recovery time was found to be shorter in tramadol group. Tramadol produced significantly less post-operative pain as compared to pentazocine lactate and meloxicam. The alterations in clinical and physiological parameters caused by tramadol, pentazocine lactate and meloxicam were found to be minimal and within the physiological limits. Tramadol was found to be more effective as compared to pentazocine lactate and meloxicam in the management of post-operative pain in canine ovariohysterectomy.

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