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Clinical and Hemato-biochemical Evaluation of Fentanyl, Midazolam, and Propofol in Boer Goats

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Abstract

This study investigated and compared the impact of Fentanyl, Midazolam, Propofol, and their combinations on clinical, biochemical, and hematological parameters in Boer goats. Twenty-four apparently healthy goats (weighing 15-20 kg and aged between 2 and 2.5 years) were randomly divided into six groups; each of them was given one of the following intravenous anesthetic protocols: Fentanyl (Group-F, 2.5 µg/kg), Midazolam (Group-M, 0.3 mg/kg), Propofol (Group-P, 6 mg/kg), or a combination of Propofol-Fentanyl (Group-PF), Midazolam-Fentanyl (Group-MF), and Midazolam-Propofol (Group-MP). Clinical evaluations, including heart rate, respiratory rate, rectal temperature, and reflexes (righting, palpebral, and pedal reflex) responses, were recorded before and at 5-minute intervals up to 30 minutes after drug administration. Blood samples were collected before anesthesia and 30 minutes post-induction to assess serum biochemical markers (ALT, AST, creatinine, urea, total protein, albumin, and globulin) and hematological indices (PCV, TEC, TLC, and Hb). Heart rate and rectal temperature significantly increased ($P < 0.05$) across all groups, while respiratory rate remained consistent. The Midazolam-Propofol group (MP) exhibited the longest duration of anesthesia (24.00±2.08 min) with complete loss of reflexes. Significant biochemical changes included increased ALT in Group M and elevated AST and albumin in Group PF. Creatinine concentrations were substantially reduced in Groups M and MP, whereas urea levels were significantly elevated in Group MP. Among the hematological parameters, hemoglobin levels were markedly higher in Group P, whereas Group M demonstrated a decreased total leukocyte count. Among all protocols, the Midazolam-Propofol combination provided the most effective and balanced anesthetic protocol for Boer goats, with stable physiological responses and manageable alterations in blood chemistry and cell counts.

Keywords: boer goats; clinical parameters; hemato-biochemical parameters; fentanyl; midazolam; propofol

Introduction

A key aspect of veterinary surgery is anesthesia, which reduces pain and physiological stress while enabling the humane execution of invasive procedures. Effective anesthesia is especially challenging in ruminants like goats due to species-specific medication reactions and the potential for side effects, including regurgitation and bloating [1].

Goats have significant value in Bangladesh because of their ability to meet protein demand. A popular exotic meat breed, Boer goats, both purebred and crossbred, are a good fit for Bangladesh's farming practices because of their rapid development and capacity to yield meat. Preoperative care of various surgical interventions in Boer goats often involves the use of various anaesthetics, which may include fentanyl, midazolam, and propofol. The balanced anaesthetic strategy minimizes the adverse effects of individual anaesthetic medications on cardiopulmonary function by combining two or more anaesthetic agents to achieve the desired components of general anaesthesia [2]. The selection and application of anaesthetic and analgesic agents, as well as the method of administering anaesthetic agents, are all dependent on the patient and the animal.

Propofol (2, 6-diisopropylphenol) is a phenolic compound unrelated to any other general anesthetics. Short-acting hypnotics like propofol are useful since they induce and recover quickly, but if administered in excess, they may result in hypotension and respiratory depression [3]. Since it has little or no analgesic property, it is recommended to combine propofol with an analgesic agent (opioid or alpha-2-adrenoreceptor agonist) for painful procedures [4]. Fentanyl, a mu (MOP) opioid agonist, is used in many species to provide analgesia during propofol anaesthesia [5]. In goats, it has a short half-life following intravenous (IV) injection, and is therefore suitable for CRI [6]. Midazolam, a water-soluble benzodiazepine, is used as a sedative, muscle relaxant, and anticonvulsant in human patients [7]. In goats, the intramuscular (IM) use causes dose-dependent sedation [8]. Midazolam administered at 0.3 mg/kg IV resulted in a 40% reduction in the dose of propofol required for induction of anaesthesia [9].

Research on the relative effects of propofol, midazolam, and fentanyl in goats is still unsatisfactory, particularly concerning biochemical markers, haematological profiles, and clinical manifestations. Investigating the physiological effects of various anaesthetics can yield significant details for enhancing anaesthesia safety and developing protocols specific to certain species. In late-preterm lambs exposed to severe hypoxia and cardiac arrest, propofol medication during pregnancy and the first few hours of life may help preserve LVEF. This intervention also reduces the release of cTnT into fetal plasma [10]. No research has been done on the influence of propofol on haematological parameters in Boer goats in either physiological or surgical conditions. During anesthesia, parameters such as hemoglobin level, packed cell volume, white blood cell count, serum creatinine, ALT, AST, and electrolyte levels provide insight into the animal's organ function, immunological status, and systemic stress response [11]. Changes in such parameters could indicate adverse outcomes or physiological changes that affect the safety and efficacy of surgery. Therefore, the goal of this research is to assess the hematological and biochemical alterations caused by propofol, midazolam, and fentanyl in Boer goats by evaluating their clinical effects and reflex responses, to improve perioperative care and anesthetic protocols in veterinary practice.

Materials and Methods

Study area and animals

The study was conducted at the Department of Surgery and Obstetrics and the Veterinary Teaching Hospital, Bangladesh Agricultural University (BAU), Mymensingh. Twenty-four clinically healthy Boer goats, aged 2-2.5 years and weighing 15-20 kg, were selected for this study. Food and water were supplied *ad libitum* throughout the study. However, food but not water was withheld 12 hours before the start of the experiment to avoid the complications of anesthetics in goats.

Experimental design

The experimental animals were randomly divided into six groups, each consisting of four goats. Drugs were administered as follows:

Group F (Fentanyl)

The animals of this group were administered fentanyl at a dose rate of 2.5 µg/kg BW. (Fentyl®, Popular Pharmaceuticals, Bangladesh) for anaesthesia. Fentanyl was injected intravenously.

Group M (Midazolam)

This group of animals was anesthetized with midazolam (Hypnofast®, Incepta Pharmaceuticals, Bangladesh). Midazolam was administered intravenously at a dose rate of 0.3 mg/kg BW.

Group P (Propofol)

This group of animals was anesthetized with Propofol (Pofol®, Popular Pharmaceuticals, Bangladesh). Propofol was administered intravenously at a dose rate of 6 mg/kg BW.

Group PF (Propofol and Fentanyl)

The animals in this group were administered a combination of Propofol (Pofol®, Popular Pharmaceuticals, Bangladesh) and fentanyl (Fentyl®, Popular Pharmaceuticals, Bangladesh) for anesthesia. Propofol (6 mg/kg) and fentanyl (2.5 µg/kg) were taken in a syringe and administered intravenously.

Group MP (Midazolam and Propofol)

The animals in this group were administered midazolam (Hypnofast®, Incepta Pharmaceuticals, Bangladesh) and Propofol (Pofol®, Popular Pharmaceuticals, Bangladesh) for anesthesia. A combination of Propofol (6 mg/kg) and midazolam (0.3 mg/kg) was taken in a syringe and administered intravenously.

Group MF (Midazolam and Fentanyl)

The animals of this group were received midazolam (Hypnofast®, Incepta Pharmaceuticals, Bangladesh) and fentanyl (Fentyl®, Popular Pharmaceuticals, Bangladesh) for anaesthesia. A combination of Midazolam (0.3 mg/kg) and fentanyl (2.5 µg/kg) was taken in a syringe and administered intravenously.

Anesthetic procedure

Before the anesthesia, the animal was placed on the table and kept in dorsal recumbency. The animal's head was securely held by assistance. The anesthetic drugs were then administered intravenously using a disposable plastic syringe (1-10 ml capacity). The induction was monitored and confirmed by inserting a needle and keeping an eye on multiple reflexes.

Clinical evaluation

Heart rate, respiratory rate, and rectal temperature were recorded at baseline and at 5, 10, and 15 minutes after the administration of various anesthetic drugs following induction. After the injection, the Depth of anesthesia was assessed using righting, palpebral, and pedal reflexes, and this monitoring was done every ten minutes until all groups had fully recovered from anesthesia. The duration from injection to loss of righting reflex was used to establish the induction time, and the restoration of the righting reflex was used to assess the animal's recovery from anesthesia. Depth of anesthesia was assessed using righting, palpebral, and pedal reflexes at 5-minute intervals.

Monitoring of physical parameters

A stethoscope was used to assess the heart rate from the lower left lateral thoracic wall. The respiration rate was determined by examining chest movement in the thoracic-abdomen, and the rectal temperature was measured with a thermometer.

Collection of blood samples

6 ml blood samples were collected using a 10 ml disposable syringe from jugular venipuncture before the administration of anesthetics and 30 minutes after anesthesia. Before the collection of blood samples, the area of the jugular vein was clipped, shaved, and aseptically prepared using 70% alcohol. 4 mL of blood was transferred immediately to a Vacutainer (clot activator tube), allowed to stay in the tube rack for serum separation, and 2 mL of blood was transferred into an EDTA tube for hematological analysis.

Hemato-biochemical analysis

For biochemical analysis, serum was separated by using centrifugation at 3000 rpm for 10 minutes and analyzed using a semi-automatic biochemistry analyzer (BS5010 Chemistry Analyzer; CURE Inc., USA). The serum samples were analyzed to assay creatinine, urea, aspartate aminotransferase (AST), alanine aminotransferase (ALT), total protein (TP), albumin, and globulin.

Hematological examinations were performed at the Clinical Pathology Laboratory, VTH, BAU to calculate packed cell volume (PCV) determined by microhematocrit centrifugation at 10,000 rpm for 5 minutes, haemoglobin (Hb) measured using the Sahli-Hellige method by comparing acid hematin color to a standard chart, total erythrocyte count (TEC) and total leukocyte count (TLC) performed using a hemocytometer and neubauer chamber under a light microscope, and erythrocyte sedimentation rate (ESR) determined using the Westergren method.

Statistical analysis

Data were expressed as mean ± standard error of the mean (SEM). One-way ANOVA was used to compare clinical parameters among groups, while independent t-tests were used for biochemical comparisons. Statistical significance was set at $P < 0.05$. Analyses were conducted using SPSS software (version 23.0; IBM Corp., Armonk, NY, USA).

Result

Effects on heart rate (HR)

The effects of different anaesthetic combinations on heart rate (HR) in Boer goats are summarized in Figure 1(A). A significant ($P<0.05$) increase in HR was observed at 5 minutes post-induction in the PF and MP groups compared to the MF group. The PF group exhibited a consistently elevated heart rate throughout the observation period, peaking at 142.00 ± 8.00 beats/min at 20 minutes. In contrast, a significant ($P<0.05$) decrease in HR was noted in the MF group at 20 and 30 minutes compared to the PF group. Goats in the MF group showed the lowest heart rate at 30 minutes (76.00 ± 0.00 beats/min), indicating a more pronounced depressive effect on cardiac function.

Effects on respiration rate (RR)

The effects of anaesthetic combinations on respiratory rate (RR) are presented in Figure 1(B). At 5 minutes post-administration, the RR significantly ($P<0.05$) increased in groups F and P compared to PF. A marked ($P<0.05$) reduction in RR was observed in group MF at 10, 20, and 30 minutes, with the highest value (36.00 ± 7.02 breaths/min) recorded at 10 minutes and a subsequent decline thereafter. The lowest RR was found in the P group at 30 minutes (17.00 ± 0.58 breaths/min), suggesting potential respiratory depression.

Effects on rectal temperature (RT)

Rectal temperature (RT) changes due to different anesthetic regimens are detailed in Figure 1(C). At 5 minutes, a significant drop in RT was observed in the MF group compared to F, M, and P groups. The lowest rectal temperature at this time was recorded in MF (100.73 ± 0.37 °F). At 30 minutes, RT significantly ($P<0.05$) increased in groups M, PF, and MP compared to F. Notably, the F group showed a marked rise in temperature at 30 minutes (108.08 ± 0.27 °F), which may suggest thermogenic side effects. The MF group maintained a consistently lower RT across all time points, indicating a more suppressive effect on thermoregulation.

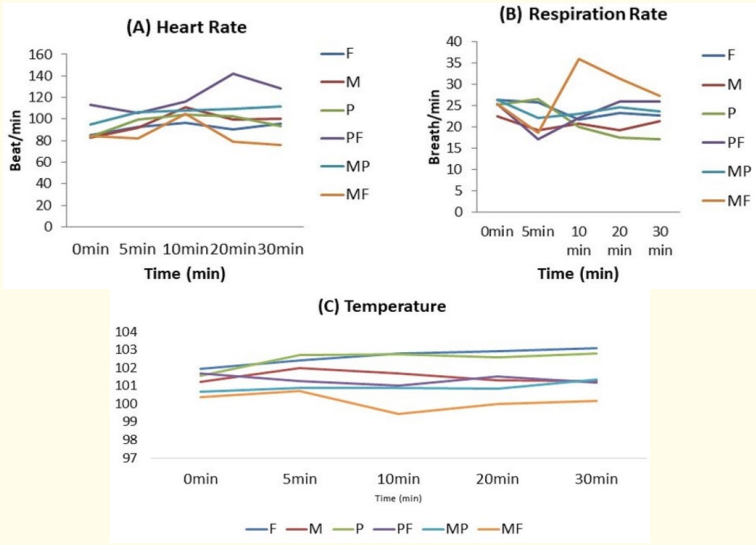

Figure 1: Effects of various anesthetics on heart rate, respiration rate and rectal temperature in boar goat.

Comparison of different anaesthetic regimens on the reflex responses

Effects of different anaesthetics on reflex responses in Boer goats are shown in Figure 2. All the animals of all groups except group F, lost the righting reflex around 1 min. The shortest time of loss of righting reflex in the animals of group MF was recorded, followed by group P, group PF, group MP, and group M. The highest and lowest time of recovery of the righting reflex was observed in group MP and group MF, respectively. The highest withdrawal time of palpebral reflex was found in group MP (24±1.70min), followed by (15.33±0.27min) in group PF, (14±0.67min) in group P, (13.75±1.24min) in group M, and (2.67±0.18min) in group MF. The highest and lowest time of recovery of pedal reflex was observed in group MP and group MF, respectively. There was no loss of reflex in animals of group F.

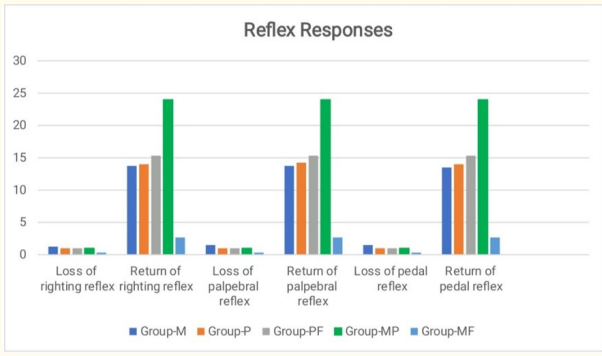

Figure 2: Effects of different anaesthetics on the reflex responses.

Comparison of different anaesthetic regimens on the onset of induction and duration of anaesthesia in Boer goats

The effect of different anaesthetics in Boer goats on the onset of induction and duration of anaesthesia is presented in Figure 3. In this study, the value of the onset of induction and duration of anaesthesia changed distinctly. The longest induction period was found in the animals of group MF (1.33±0.67min) and the lowest induction period was found in the animals of group M (0.75±0.25min) The highest duration of anaesthesia was found in the animals of group MP (24.00±2.08min) followed by group P (14.25±2.18min), group M (11.75±5.14min), (10.67±2.33min) and group MF (4.67±2.40min). No onset of induction was observed in animals of group F.

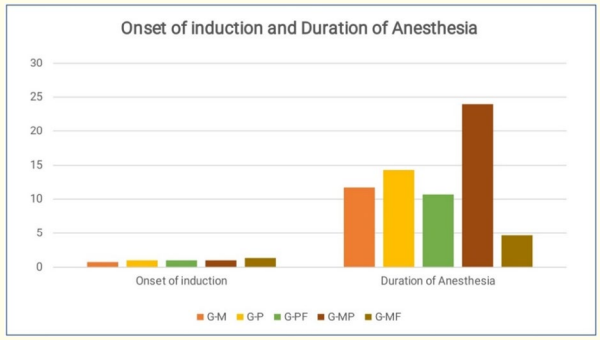

Figure 3: Effects of different anaesthetics on the Onset of induction and Duration of Anesthesia.

Effects of different anaesthetics on biochemical parameters in Boer goats

At 30 minutes post-induction, significant (P < .05) variations were observed in several biochemical parameters among the treatment groups, as shown in Table 1. Alanine transaminase (ALT) levels increased slightly in groups F, M, and MP, while significant decreases were noted in group PF (35.90 ± 25.78 to 26.74 ± 24.21 IU/L) and group P (41.86 ± 13.77 to 31.74 ± 22.68 IU/L). AST levels increased significantly in the propofol-fentanyl group (29.22 ± 1.36 to 84.52 ± 39.12 IU/L), midazolam-propofol group (32.41 ± 0.13 to 55.25 ± 18.72 IU/L), and midazolam-fentanyl group (31.02 ± 4.80 to 69.79 ± 29.42 IU/L) (P<0.05). Creatinine concentrations decreased significantly in groups F (3.35 ± 0.96 to 1.28 ± 0.39 mg/dL), P, M, and MP, pointing to diminished muscle activity or altered renal perfusion at the time of anesthesia, while a non-significant increase was seen in the midazolam-fentanyl group. Blood urea decreased significantly in the midazolam group (126.99 ± 31.37 to 64.39 ± 11.77 mg/dL) and increased significantly in the midazolam-propofol (67.90 ± 27.73 to 73.54 ± 6.73 mg/dL) and midazolam-fentanyl groups (46.16 ± 6.09 to 70.21 ± 17.63 mg/dL).No significant changes in globulin levels were detected across groups; however, group MF exhibited the highest value compared to the others. Albumin levels decreased significantly in groups F (2.86 ± 0.41 g/dL) and MF post-induction, whereas group PF showed a significant increase (6.05 ± 0.72 g/dL) compared to both its baseline and other groups (P and MP). Consequently, total protein decreased significantly in fentanyl (16.38 ± 2.91 to 13.15 ± 0.29 g/dL), midazolam-propofol (14.23 ± 0.03 to 14.48 ± 0.58 g/dL), and midazolam-fentanyl groups (16.65 ± 2.11 to 14.27 ± 0.50 g/dL) (P<0.05).

Parameter	*Group*	*Preanesthetic Control*	*30 min after induction*
ALT (IU/L)	F	35.36±21.24	44.72±19.43
	M	110.70±75.01	130.07±30.05 [x]
	P	41.86±13.77	31.74±22.68 [y]
	PF	19.90±5.76	26.74±24.21 [y]
	MP	32.97±2.72	37.68±20.88 [y]
	MF	44.12±16.03	42.09±20.97 [y]

AST (IU/L)	F	28.15±0.29	28.85±4.42 ^{x}
	M	42.95±10.41	21.33±4.46 ^{x}
	P	25.90±9.92	24.79±11.26 ^{x}
	PF	29.22±1.36^{a}	84.52±39.12^{by}
	MP	32.41±0.13	55.25±18.72 ^{xy}
	MF	31.02±4.80 ^{a}	69.79±29.42 ^{bxy}
Creatinine (mg/dL)	F	3.35±0.96	1.28±0.39 ^{x}
	M	1.76±1.30	0.94±0.41 ^{x}
	P	2.11±0.27 ^{a}	1.19±0.57 ^{b}
	PF	3.63±0.68	2.72±0.40 ^{y}
	MP	2.60±0.45	0.97±0.36 ^{x}
	MF	2.31±0.07	3.27±0.79 ^{y}
Urea (mg/dL)	F	78.13±27.13	71.95±17.39
	M	126.99±31.37 ^{x}	64.39±11.77
	P	33.33±6.74 ^{y}	44.13±8.15
	PF	98.81±6.46	69.74±9.00
	MP	67.90±27.73 ^{a}	73.54±6.73 ^{b}
	MF	46.16±6.09 ^{y}	70.21±17.63
Globulin (g/dL)	F	10.16±0.37	10.29±0.18
	M	10.34±0.06	10.45±0.07
	P	10.40±0.08	10.04±0.42
	PF	10.00±0.21	9.17±1.17
	MP	10.29±0.01	9.09±1.11
	MF	10.42±0.07	10.46±0.11
Albumin (g/dL)	F	6.22±2.54 ^{a}	2.86±0.41^{bx}
	M	4.39±0.43	3.17±0.39 ^{x}
	P	3.51±0.55	4.86±0.78 ^{yz}
	PF	3.76±0.08 ^{a}	6.05±0.72 ^{by}
	MP	3.94±0.02	5.38±0.75 ^{y}
	MF	6.23±2.17 ^{a}	3.81±0.41 ^{bxz}
Total Protein (g/dL)	F	16.38±2.91^{a}	13.15±0.29 ^{b}
	M	14.73±0.48	13.62±0.36
	P	13.91±0.63	14.90±0.86
	PF	13.75±0.29	15.22±0.80
	MP	14.23±0.03 ^{a}	14.48±0.58 ^{b}
	MF	16.65±2.11^{a}	14.27±0.50^{b}

Table 1: Effects of different anaesthetics on biochemical parameters in Boer goats (Mean ± SEM).

Values with different superscript letters (a, b) in the same row and different superscript letters (x, y, z) in the same column differed significantly at P< 0.05 or less.

Effects of different anaesthetics on hematological parameters in Boer goats

At 30 minutes post-induction, significant ($P < .05$) changes were observed in several hematological parameters among the treatment groups (Table 2). Packed cell volume (PCV) increased significantly in groups F (21.75 ± 0.25 to 23.31 ± 1.23%), P (21.10 ± 0.10 to 25.25 ± 1.25%), and MP, while group MF showed a decrease (21.50 ± 0.50 to 20.63 ± 1.14%). Erythrocyte sedimentation rate (ESR) decreased significantly in groups F and M, while group MF exhibited an increase post-induction (1.00 ± 0.00 to 1.18 ± 0.12%). Hemoglobin (Hb) concentration increased significantly in group F (7.25 ± 0.25 to 8.05 ± 1.18 g/dL), and the highest Hb level was recorded in group P (9.75 ± 0.48 g/dL), whereas other groups showed non-significant changes. Total erythrocyte count (TEC) increased in all groups post-induction, with notable rise in the propofol group (4.05 ± 0.05 to 10.13 ± 0.90 $\times 10^6/\mu L$) and group MF (5.15 ± 1.05 to 13.25 ± 1.55 $\times 10^6/\mu L$), while the lowest pre-induction value was recorded in group P. Total leukocyte count (TLC) significantly decreased in group M (22.20 ± 2.20 to 13.70 ± 0.37 $\times 10^3/\mu L$), while changes in other groups were non-significant.

Parameter	*Group*	*Preanesthetic Control*	*30 min after induction*
PCV (%)	F	21.75±0.25 [a]	23.31±1.23 [bxy]
	M	21.75±0.75	24.75±1.90
	P	21.10±0.10 [x]	25.25±1.25 [xy]
	PF	21.75±0.25	22.19±0.62 [y]
	MP	22.00±0.50	24.63±0.24 [x]
	MF	21.50±0.50	20.63±1.14
ESR (%)	F	1.00±0.00	0.88±0.22 [xy]
	M	1.13±0.13	0.75±0.14 [y]
	P	1.00±0.00	0.94±0.21
	PF	1.00±0.00	1.13±0.13 [x]
	MP	1.13±0.13	0.78±0.24
	MF	1.00±0.00	1.18±0.12
Hb (g%)	F	7.25±0.25 [ax]	8.05±1.18 [bx]
	M	7.60±0.40	7.88±0.43 [xy]
	P	7.90±0.10	9.75±0.48 [xy]
	PF	7.45±0.05	7.55±0.49 [x]
	MP	8.00±0.00 [y]	7.73±0.43 [y]
	MF	7.80±0.20	7.65±0.46 [y]
TEC(10^6/ µL)	F	7.30±1.30	10.83±1.55 [x]
	M	7.35±1.15	12.20±1.62 [y]
	P	4.05±0.05 [a]	10.13±0.90 [bxy]
	PF	7.20±1.20	11.63±1.08 [y]
	MP	5.20±1.00	9.70±1.89 [y]
	MF	5.15±1.05 [x]	13.25±1.55 [y]
TLC (10^3/ µL)	F	22.35±2.15	17.45±1.25
	M	22.20±2.20 [a]	13.70±0.37 [b]
	P	14.45±0.05	19.55±2.95
	PF	22.35±2.15	16.95±2.08
	MP	19.70±4.70	19.42±3.17
	MF	19.70±5.30	15.57±1.64

Table 2: Effects of different anaesthetics on hematological parameters in Boer goats (Mean ± SEM).

Values with different superscript letters (a, b) in the same row and different superscript letters (x, y, z) in the same column differed significantly at P< 0.05 or less.

Discussion

This study aimed to evaluate the clinical, biochemical, and hematological effects of different anesthetic protocols in Boer goats. To our knowledge, no previous research has focused on comparing the effects of various anaesthetics on different physiological and hematobiological parameters in Boer goats, although it is a valuable breed.

A significant (P<0.05) increase in heart rate (HR) was observed across all groups at 30 minutes, particularly in groups PF and MP, which aligns with previous findings [12]. Midazolam likely contributed to this increase via sympathetic stimulation, warranting caution in animals with cardiovascular conditions [13]. Therefore, it is highly recommended not to use Midazolam in cardiovascular patients. In contrast, propofol alone initially increased HR but later caused a decrease during deeper anesthesia, consistent with reports by [14] and [15]. In the present study, heart rate significantly increased after induction and decreased during maximum depth of anesthesia when propofol was used alone in Boer goats.

Rectal temperature (RT) increased significantly at 10 minutes in all groups, with the highest in group F. Propofol inhibits central thermoregulatory control, thus causing vasodilation, leading to substantial redistribution hypothermia that persists throughout surgery. Intravenous administration of fentanyl resulted in a transitory increase in rectal temperature. Propofol-induced vasodilation and fentanyl's transient hyperthermic effect may explain these changes. However, a study revealed that the rectal temperature did not change significantly before the evoking time in a propofol combination protocol [16]. Midazolam effectively reduced the required dose of propofol but caused hypersalivation in all animals. Yet again, an earlier study reported a non-significant drop in rectal temperature as well as adverse effects, including mild to excessive salivation, in addition to other symptoms [17].

Induction of anesthesia with propofol in animals and humans causes depression of respiratory function, expressed by a decrease in tidal volume and respiratory rate. Apnoea can occur, and its incidence is reported to be dependent on dose, speed of injection, concomitant premedication, and the presence of hyperventilation and hyperoxia [5]. Respiratory rate (RR) decreased in all groups, particularly in group P, consistent with the known respiratory depressant effects of propofol [6]. Reflex assessment revealed the fastest onset in group M and the longest anesthetic duration in group MP. In this study, no surgery was performed, and so the surgical anaesthetic duration was observed as reported in the literature by assessment of the righting reflex, palpebral reflex, and pedal withdrawal reflex. Loss and return of reflexes varied with drug combinations, reflecting the depth and duration of anesthesia [18].

Biochemical analysis revealed a significant decrease in total protein in groups F, MP, and MF following induction of anesthesia as well as serum AST activity showed a significant increase in PF, MP, and MF groups, whereas no significant alterations were observed in other groups. These results partly contradict previous reports of significant increases in hepatic enzymes under anesthesia, suggesting that the changes seen in this investigation were rather limited and transient [19, 20]. Serum urea and creatinine levels dropped in the F,M,P and MP protocols suggesting that renal perfusion was changed during anesthesia rather than renal failure. There have been earlier mentions of similar transitory decreases in renal biomarkers during anesthesia [21]. Therefore, the anesthetics appear safe to use in healthy animals, while caution may be advised in animals with pre-existing renal dysfunction because these changes stayed within physiological limits.

Hematologically, F,P and MP groups showed a significant increase in PCV, while remaining within normal physiological ranges in other groups that are identical to the earlier results [22, 23]. Total erythrocyte count increased significantly in all anesthetic protocols, whereas a significant decrease in total leukocyte count was observed in the midazolam group. There were no clinically significant changes in hemoglobin concentration or ESR. These results are in agreement with previous studies showing that goats undergoing complete intravenous anesthesia experienced minimal hematological disturbances [24]. These findings suggest that the anesthetic combinations used were generally safe, with minimal physiological disturbance in healthy Boer goats.

Conclusions

Based on the findings of the present study, it can be concluded that Midazolam-Propofol resulted rapid onset and longer anesthetic duration, which is useful for clinical practice and surgical procedures of moderate or longer duration. The induction of anaesthesia was not observed in all goats when Fentanyl alone was administered. Clinical parameters (heart rate, respiration rate, and rectal temperature) were significantly changed at different time intervals throughout the anaesthetic period in goats. The combination of PF, MP, and MF exerts some systemic effect on serum biochemistry, hematology, and on some vital organs like the liver and kidney, which are responsible for detoxification and elimination of waste products.

We did not perform any surgery as part of this study, so further research is needed to determine the usefulness of this combination for surgical operations. Investigators should consider this combination when planning invasive research in goats.

Conflict of Interest

The authors declare that they have no competing interests.

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References

1. Hall LW, Clarke KW and Trim CM. "Veterinary Anaesthesia". Saunders (2014): 693.
2. Reid J, Nolan AM and Welsh E. "Propofol as an induction agent in the goat: a pharmacokinetic study". Journal of Veterinary Pharmacology and Therapeutics 16.4 (1993): 488-493.
3. Muir WW and Gadawski JE. "Cardiovascular effects of a high dose of romifidine in propofol-anesthetized cats". American Journal of Veterinary Research 63.9 (2002): 1241-1246.
4. Mama KR., et al. "Comparison of two techniques for total intravenous anesthesia in horses". American Journal of Veterinary Research 59.10 (1998): 1292-8.
5. Smith JA., et al. "Adverse effects of administration of propofol with various preanesthetic regimens in dogs". Journal of the American Veterinary Medical Association 202.7 (1993): 1111-1115.
6. Carroll GL., et al. "Detomidine-Butorphanol-Propofol for carotid artery translocation and castration or ovariectomy in goats". Veterinary Surgery 27.1 (1998): 75-82.
7. Cao JL., et al. "Pretreatment with midazolam suppresses morphine withdrawal response in mice and rats". Acta Pharmacologica Sinica 23.8 (2002): 685-690.
8. Stegmann GF and Bester L. "Sedative-hypnotic effects of midazolam in goats after intravenous and intramuscular administration". Veterinary Anaesthesia and Analgesia 28.1 (2001): 49-55.
9. Dzikitia TB., et al. "Sedative and cardiopulmonary effects of acepromazine, midazolam, butorphanol, acepromazine-butorphanol and midazolam-butorphanol on propofol anaesthesia in goats". Journal of the South African Veterinary Association 80.1 (2009): 10-16.
10. Seehase M., et al. "Propofol administration to the fetal-maternal unit reduces cardiac injury in late-preterm lambs subjected to severe prenatal asphyxia and cardiac arrest". Pediatric Research 73.1-4 (2013): 427-434.
11. Kumar A., et al. "Evaluation of propofol and ketofol as induction agents in dogs premedicated with butorphanol-diazepam for

isoflurane anaesthesia". Indian Journal of Veterinary Surgery 41.2 (2020): 87-91.

12. Oguntoye C and Oke B. "A comparison of xylazine/ketamine, diazepam/ketamine and acepromazine/ketamine anaesthesia in rabbit". Sokoto Journal of Veterinary Sciences 12.3 (2015): 21.
13. Win NN., et al. "The different effects of intravenous propofol and midazolam sedation on hemodynamic and heart rate variability". Anesthesia & Analgesia 101.1 (2005): 97-102.
14. Lin HC., et al. "Anesthesia in sheep with propofol or with xylazine-ketamine followed by halothane". Veterinary Surgery 26.3 (1997): 247-252.
15. Brüssel T., et al. "Hemodynamic and cardiodynamic effects of propofol and etomidate: negative inotropic properties of propofol". Anesthesia & Analgesia 69.1 (1989): 35-40.
16. Elkasapy A. "Xylazine, ketamine and propofol general anesthesia for laparoscopic intervention in goats". Benha Veterinary Medical Journal 45.2 (2023): 41-45.
17. Asif M., et al. "Effects of detomidine and midazolam administered alone or combined, on induction dose and quality of propofol and ketamine anesthesia in goats". Journal of Animal and Plant Sciences 31.2 (2020): 441-449.
18. Karasu A., et al. "Evaluation of the anesthetic effects of xylazine-ketamine, xylazine-tiletamine-zolazepam and tiletamine-zolazepam using clinical and laboratory parameters in rabbits". Medycyna Weterynaryjna-Veterinary Medicine-Science and Practice 74.10 (2018).
19. Abdulrazaq AW., et al. "Study the effect of ketamine, xylazine and their combination on liver and kidney features in rabbits". Annals of R.S.C.B. 25.6 (2021): 3427-3432.
20. Antoniades CG., et al. "The importance of immune dysfunction in determining outcome in acute liver failure". Journal of Hepatology 49.5 (2008): 845-861.
21. Arulkumaran N., et al. "Management of the dialysis patient in general intensive care". British Journal of Anaesthesia 108.2 (2012): 183-192.
22. Potter J., et al. "Preliminary investigation into change in packed cell volume (PCV) after administration of two premedication protocols followed by induction and maintenance of anaesthesia in goats". Emerging Animal Species 5 (2022): 100012.
23. González Gil A., et al. "Effects of the anaesthetic/tranquillizer treatments on selected plasma biochemical parameters in NZW rabbits". Laboratory Animals 37.2 (2003): 155-161.
24. Ragab G., et al. "Clinicophysiological and hematobiochemical effect of dexmedetomidine or diazepam with ketamine and propofol in total intravenous anesthesia in goats". Beni-Suef University Journal of Basic and Applied Sciences 11.1 (2022): 54.