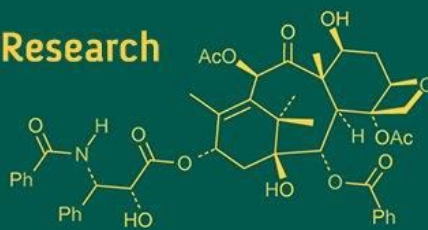


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; 10(4): 304-309
www.biochemjournal.com
Received: 06-02-2026
Accepted: 09-03-2026

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Comparative evaluation of atracurium and rocuronium as muscle relaxants in buffalo

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i4d.8116>

Abstract

The efficacy and safety of neuromuscular blocking agent atracurium (Group 1) and rocuronium (Group 2) were compared in male buffaloes of eight to twenty four months of age. Each group comprises of five animals. Atracurium at a dose rate of 0.4 mg/Kg body weight and rocuronium at 0.2 mg/Kg body weight were given intravenously. The parameters were studied under different headings viz. Behavioural observations, Physiological parameters, Haematological parameters and Plasma biochemical parameters. After this experimental study it was concluded that rocuronium was found to be better neuromuscular blocking agent as compared to atracurium in buffaloes.

Keywords: Atracurium, buffalo, muscle relaxant, neuromuscular blocking agents, Rocuronium

Introduction

Muscle relaxation is an integral component of anaesthetic triad (Amnesia, analgesia and muscle relaxation) for achieving smooth and safe surgical procedures. Orthopedic and thoracic surgeries are difficult to perform without adequate muscle relaxation especially when the subject is a large muscular species. So, neuromuscular blocking (NB) agents have become an essential component of anaesthetic regimen for such surgeries. NB agents cause little or no significant systemic effects. It is possible to produce quickly and with certainty, any degree of muscle relaxation without influencing the excitability and functioning of the central nervous and cardiovascular systems (Hall *et al.*, 2001) [7].

Neuromuscular blocking agents interfere with acetylcholine inhibiting receptor-coupled trans-membrane ion movements necessary for muscle contraction (Bouzat *et al.*, 2004 and Unwin, 2005) [2, 14] thereby resulting into skeletal muscle paralysis and muscular relaxation (Kita and Goodkin, 2000) [10]. NB agents reduces the dose of anaesthesia, facilitate endotracheal intubation, skeletal muscle tone relaxation at light planes of anaesthesia, orthopedic manipulations and prevention of patient movement during delicate ocular, neurological, or cardiac surgery (Taylor, 2006; and Martinez and Keegan, 2007) [13, 11].

The introduction of NB drugs into clinical practice has revolutionized the practice of anaesthesia in human patients. It has improved the safety and results of many established surgical procedures, as they produce negligible effect on heart rate and arterial blood pressure in anaesthetized patients (Barnes *et al.*, 1982) [1]. The literature related to evaluation and use of NB drugs in bovines and specially in buffaloes are scarce, however, the increased value of individual buffalo leads to increased demand for orthopedic and thoracic surgeries in these animals.

Atracurium and rocuronium are recent non-depolarising neuromuscular blocking agents with minimum depressant effects on vital systems in different species. So, the study was planned to evaluate their safety and efficacy in buffalo for their intended future use.

Materials and Methods

Ten apparently healthy male buffaloes of eight to twenty four months age were randomly divided into two groups of five animals in each group. All animals were kept on standard ration and under similar management conditions. Pilot trials were conducted to standardize the dose and route of administration of drugs. A washout period of one week was given before reusing buffalo calves for the next experiment.

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Atracurium was used at different dose rates of 0.1, 0.2, 0.3, 0.35, 0.375 and 0.4 mg per kg body weight and Rocuronium at 0.15, 0.2, 0.25 and 0.3 mg per kg body weight intravenously. Based on the results of pilot trials, the dose rate of atracurium and rocuronium was chosen as 0.4 mg/kg and 0.2 mg/kg body weight intravenously, respectively for further study. The facility of positive pressure ventilation was kept available throughout the experiment. All the animals were kept off feed for 24 hours and off water for 12 hours prior to experiment.

The animals were comfortably secured in standing position inside a chute, physiological parameters were recorded, blood samples were collected and then atracurium² or rocuronium³ were injected in the jugular vein as per the protocol and the parameters were recorded.

The behavioral observations included

- Weak time: Time elapsed from administration of drug to onset of ataxia
- Down time: Time elapsed from administration of drug to onset of sternal or lateral recumbency
- Body reflexes i.e. paddling of limbs, loss of palpebral reflex, loss of corneal reflex, salivation, loss of tongue reflex, loss of swallowing reflex, and loss of jaw tone, tail tone, forelimb tone, hind limb tone, prepuce tone, and scrotal tone.
- Recovery from effect of drugs was taken to have occurred by
 - Extubation time
 - Return to sternal recumbency
 - Standing time with ataxia
 - Walking with ataxia
 - Walking without ataxia

Physiological parameters like rectal temperature along with ambient temperature, heart rate and respiratory rate were recorded before drug administration, at 5, 10, 15, 30, 45 and 60 minutes of administration of drug, at recovery and at 24 hours of recovery.

Haematological and Biochemical Study

For haematological and biochemical analysis, blood samples

were aseptically collected from jugular venipuncture before drug administration, at five minute of injection, at recovery and at 24 hours of recovery. Haematological parameters were estimated in automatic analyser MS4 after collecting blood samples in vials containing EDTA.

For analysis of biochemical parameters blood was collected in two sets of test tubes for each animal. One containing 3.8% sodium fluoride solution (10 mg/ml of blood) for estimation of glucose and other set containing heparin (10 units/ml) for estimation of blood urea nitrogen, creatinine, bilirubin, cortisol, cholesterol, triglycerides, total plasma proteins, albumin, alanine amino transferase, aspartate amino transferase, lactate dehydrogenase, gamma glutamyl transferase, alkaline phosphatase, calcium, phosphorus, sodium, potassium and chloride. Plasma was harvested by centrifugation at 3000 rpm for 20 minutes and then stored at -20 °C. Biochemical parameters were analysed with automatic analyzer using commercially available standard system pack kits. Sodium, potassium and chloride were analyzed with automatic electrolyte analyzer.

The statistical analysis of data was done by one-way-analysis of variance and Duncan's multiple range test (Duncan, 1955) [5]. The comparison between the groups had been analyzed using unpaired t-test. The significant difference was considered if $p < 0.05$.

Results and Discussion

The recorded lower weak time, down time, time for chin on ground, turning of neck, lateral recumbency, salivation, mouth gag application and intubation time were significantly lower for rocuronium than atracurium (Table-1). This shows the rapid onset of action of rocuronium as compared to atracurium. Whalley *et al.*, 1998 [15] also reported to faster tracheal intubation on rocuronium administration, however, extubation time, regaining of sternal recumbency, standing with ataxia, standing without ataxia and walking with ataxia did not differ significantly between rocuronium and atracurium. The time of spontaneous recovery of train of four twitches to 70% was also similar for both agents. Cason *et al.*, 1990 [4] have also reported similar findings.

Table 1: Means $\pm$ S.E. in min. for different behavioural characteristics induced by administration of atracurium and rocuronium in buffaloes.

Parameters	Group 1	Group 2	T value
	Mean $\pm$ SE (min.)	Mean $\pm$ SE (min.)	
Weak time	1.02 $\pm$ 0.17	0.53 $\pm$ 0.02	2.92*
Down time	1.10 $\pm$ 0.15	0.62 $\pm$ 0.02	3.17*
Chin on ground	1.21 $\pm$ 0.16	0.67 $\pm$ 0.04	3.23*
Turning of neck	1.50 $\pm$ 0.27	0.73 $\pm$ 0.03	2.78*
Lateral recumbency	1.77 $\pm$ 0.29	0.98 $\pm$ 0.03	2.65*
Paddling of limbs	3.07 $\pm$ 0.14	2.63 $\pm$ 0.39	1.05 ^{NS}
Salivation	6.18 $\pm$ 0.91	3.56 $\pm$ 0.14	2.85*
Mouth gag application	7.92 $\pm$ 1.03	4.54 $\pm$ 0.18	3.24*
Intubation	8.91 $\pm$ 0.59	6.52 $\pm$ 0.16	3.90**
Extubation	24.66 $\pm$ 1.24	22.78 $\pm$ 0.68	1.33 ^{NS}
Regaining of sternal recumbency	29.56 $\pm$ 1.23	26.98 $\pm$ 0.64	1.86 ^{NS}
Standing with ataxia	31.01 $\pm$ 1.21	28.42 $\pm$ 0.60	1.92 ^{NS}
Walking with ataxia	32.03 $\pm$ 1.23	29.00 $\pm$ 0.63	2.19 ^{NS}
Walking without ataxia	33.65 $\pm$ 1.18	31.22 $\pm$ 0.76	1.73 ^{NS}

Note: *-significant at 5% level ($p < 0.05$).

** -significant at 1% level ($p < 0.01$).

NS-non significant.

The time for the loss of tongue reflex and jaw tone in buffaloes was markedly less for rocuronium as compared to atracurium. Rocuronium also took lower time for loss of swallowing reflex, fore limb tone, hind limb tone, prepuce and scrotal tone was also recorded for rocuronium than

atracurium which may be due to faster onset of action of former than later (Whalley *et al.*, 1998) [15]. However, there was no significant difference in regain of any reflexes between the two drugs (Table-2).

Table 2: Means $\pm$ S.E. in min. for different body reflexes induced by administration of atracurium and rocuronium in buffaloes.

Parameters	Group 1	Group 2	T Value	Group 1	Group 2	T Value
Reflex	Loss	Loss		Gain	Gain	
	Mean $\pm$ SE (Min.)	Mean $\pm$ SE (Min.)		Mean $\pm$ SE (Min.)	Mean $\pm$ SE (Min.)	
Tongue reflex	6.67 $\pm$ 0.21	4.37 $\pm$ 0.55	3.89**	14.95 $\pm$ 1.00	13.88 $\pm$ 0.42	1.0 ^{NS}
Swallowing reflex	8.42 $\pm$ 0.77	5.75 $\pm$ 0.35	3.16*	22.30 $\pm$ 1.16	19.33 $\pm$ 0.50	2.25 ^{NS}
Jaw tone	7.12 $\pm$ 0.54	4.07 $\pm$ 0.41	4.52**	25.91 $\pm$ 1.20	23.08 $\pm$ 0.60	2.10 ^{NS}
Tail tone	3.23 $\pm$ 0.39	2.54 $\pm$ 0.36	1.31 ^{NS}	21.50 $\pm$ 1.20	18.09 $\pm$ 1.66	1.66 ^{NS}
Fore limb tone	6.93 $\pm$ 1.45	2.30 $\pm$ 0.37	3.09*	23.48 $\pm$ 2.17	21.58 $\pm$ 1.65	0.7 ^{NS}
Hind limb tone	7.92 $\pm$ 1.41	3.01 $\pm$ 0.24	3.22*	21.56 $\pm$ 0.75	20.00 $\pm$ 1.95	0.75 ^{NS}
Prepuce tone	10.42 $\pm$ 0.92	7.18 $\pm$ 0.36	3.29*	21.75 $\pm$ 0.45	20.44 $\pm$ 0.73	1.52 ^{NS}
Scrotal tone	11.97 $\pm$ 1.57	7.19 $\pm$ 0.35	2.97*	24.39 $\pm$ 0.70	22.11 $\pm$ 1.31	1.53 ^{NS}

Note: *-significant at 5% level ($p < 0.05$).

** -significant at 1% level ($p < 0.01$).

NS-non significant.

There was no significant difference in physiological parameters induced after administration of NB drugs (Table

3). The difference in the base values was within the normal physiological limits (Hafez, 1968).

Table 3: Effect of atracurium (Group 1) and rocuronium (Group 2) administration on rectal temperature, Heart rate and respiration rate in buffaloes as Mean $\pm$ S.E.

Time Frame	Before drug admn.	At 5 min.	At 10 min.	At 15 min.	At 30 min.	At 45 min.	At recovery	At 24 hrs. of recovery
Groups → Parameters ↓	Group1	Group1	Group1	Group1	Group1	Group1	Group1	Group1
	Group2	Group2	Group2	Group2	Group2	Group2	Group2	Group2
Rectal Temp.	37.5 $\pm$ 0.23	37.38 $\pm$ 0.23	37.06 $\pm$ 0.24	37.14 $\pm$ 0.29	37.18 $\pm$ 0.15	37.26 $\pm$ 0.19	37.66 $\pm$ 0.26	37.44 $\pm$ 0.28
	37.46 $\pm$ 0.35	37.12 $\pm$ 0.48	37.36 $\pm$ 0.45	37.06 $\pm$ 0.47	37.14 $\pm$ 0.24	37.12 $\pm$ 0.19	37.24 $\pm$ 0.26	37.6 $\pm$ 0.17
T value	0.096 ^{NS}	0.49 ^{NS}	0.58 ^{NS}	0.14 ^{NS}	0.14 ^{NS}	0.52 ^{NS}	1.15 ^{NS}	0.49 ^{NS}
Heart Rate	56.2 $\pm$ 5.50	97.4 $\pm$ 6.68	65.6 $\pm$ 4.02	52.2 $\pm$ 1.28	55.2 $\pm$ 2.87	57.4 $\pm$ 4.12	56 $\pm$ 2.47	56.4 $\pm$ 3.19
	51.6 $\pm$ 1.89	89.8 $\pm$ 3.77	76 $\pm$ 4.37	60.4 $\pm$ 3.33	54.4 $\pm$ 2.01	51 $\pm$ 1.30	51.2 $\pm$ 1.07	51.6 $\pm$ 1.81
T value	0.79 ^{NS}	0.99 ^{NS}	1.75 ^{NS}	2.3 ^{NS}	0.23 ^{NS}	1.48 ^{NS}	1.78 ^{NS}	1.31 ^{NS}
Resp. Rate	18.8 $\pm$ 0.86	11.2 $\pm$ 0.97	10.4 $\pm$ 0.68	8.2 $\pm$ 0.58	9.6 $\pm$ 0.81	10.6 $\pm$ 0.51	14.2 $\pm$ 0.66	19.8 $\pm$ 0.66
	22.6 $\pm$ 1.21	12.2 $\pm$ 1.16	10 $\pm$ 0.84	7.6 $\pm$ 0.93	10.2 $\pm$ 0.97	11.6 $\pm$ 1.21	14.4 $\pm$ 0.93	20.2 $\pm$ 0.67
T value	2.56*	0.66 ^{NS}	0.37 ^{NS}	0.55 ^{NS}	0.47 ^{NS}	0.76 ^{NS}	0.18 ^{NS}	0.43 ^{NS}

Note: *-significant at 5% level ($p < 0.05$).

** -significant at 1% level ($p < 0.01$).

NS-non significant.

Hematological Parameters

The haematological parameters of the animals are recorded in Table-4 showing no significant variation.

Table 4: Effects of atracurium (Group 1) and rocuronium (Group 2) administration on haematological parameters in buffaloes Mean $\pm$ S.E.

Parameters	Groups	Before drug admn.	At 5 min.	At recovery	At 24 hrs. of recovery
Haemoglobin (g/dl)	Group 1	8.80 $\pm$ 0.55	11.38 $\pm$ 0.52	10.06 $\pm$ 1.50	9.38 $\pm$ 0.57
	Group 2	9.28 $\pm$ 0.38	11.12 $\pm$ 0.52	9.00 $\pm$ 0.69	9.42 $\pm$ 0.40
	T value	0.72 ^{NS}	0.36 ^{NS}	0.64 ^{NS}	0.06 ^{NS}
PCV (%)	Group 1	30.90 $\pm$ 1.56	33.86 $\pm$ 1.31	33.06 $\pm$ 3.81	31.40 $\pm$ 1.21
	Group 2	34.60 $\pm$ 1.18	34.64 $\pm$ 1.22	32.14 $\pm$ 0.75	34.78 $\pm$ 0.98
	T value	1.89 ^{NS}	0.44 ^{NS}	0.24 ^{NS}	2.17 ^{NS}
TEC ($\times 10^6/\text{mm}^3$)	Group 1	6.12 $\pm$ 0.45	7.69 $\pm$ 0.37	6.57 $\pm$ 0.93	5.99 $\pm$ 0.30
	Group 2	7.17 $\pm$ 0.21	7.60 $\pm$ 0.38	6.42 $\pm$ 0.23	7.40 $\pm$ 0.25
	T value	2.11 ^{NS}	0.18 ^{NS}	0.15 ^{NS}	3.63 ^{**}
TLC ($\times 10^3/\text{mm}^3$)	Group 1	8.58 $\pm$ 1.43	10.44 $\pm$ 1.33	9.38 $\pm$ 1.04	8.18 $\pm$ 1.62
	Group 2	9.15 $\pm$ 0.53	9.66 $\pm$ 1.09	9.01 $\pm$ 0.85	9.26 $\pm$ 0.70
	T value	0.38 ^{NS}	0.45 ^{NS}	0.28 ^{NS}	0.61 ^{NS}
Total Platelet count ($\times 10^3/\text{mm}^3$)	Group 1	217.20 $\pm$ 22.68	236.00 $\pm$ 21.50	210.40 $\pm$ 23.80	225.60 $\pm$ 24.03
	Group 2	221.40 $\pm$ 12.33	239.00 $\pm$ 13.13	241.00 $\pm$ 13.94	204.80 $\pm$ 10.78
	T value	0.16 ^{NS}	0.12 ^{NS}	1.11 ^{NS}	0.79 ^{NS}
Lymphocytes (%)	Group 1	53.72 ^a $\pm$ 3.39	56.64 ^a $\pm$ 2.44	52.88 ^a $\pm$ 2.07	61.26 ^a $\pm$ 6.54
	Group 2	52.34 ^a $\pm$ 2.46	52.22 ^a $\pm$ 2.27	57.24 ^a $\pm$ 1.52	52.88 ^a $\pm$ 2.40
	T value	0.33 ^{NS}	1.33 ^{NS}	1.69 ^{NS}	1.20 ^{NS}
Monocytes (%)	Group 1	2.04 $\pm$ 0.38	1.84 $\pm$ 0.20	2.22 $\pm$ 0.23	1.58 $\pm$ 0.12
	Group 2	2.00 $\pm$ 0.08	1.96 $\pm$ 0.07	2.12 $\pm$ 0.07	1.98 $\pm$ 0.11
	T value	0.10 ^{NS}	0.56 ^{NS}	0.42 ^{NS}	2.44 [*]
Granulocytes (%)	Group 1	44.24 $\pm$ 3.04	41.52 $\pm$ 2.36	44.90 $\pm$ 1.89	37.16 $\pm$ 6.48
	Group 2	45.66 $\pm$ 2.38	45.82 $\pm$ 2.25	40.64 $\pm$ 1.56	45.14 $\pm$ 2.36
	T value	0.37 ^{NS}	1.32 ^{NS}	1.74 ^{NS}	1.16 ^{NS}
MCV (fl)	Group 1	48.90 $\pm$ 1.58	49.30 $\pm$ 1.66	49.20 $\pm$ 1.51	48.60 $\pm$ 1.48
	Group 2	51.98 $\pm$ 0.99	52.08 $\pm$ 0.84	51.70 $\pm$ 0.93	52.24 $\pm$ 0.95
	T value	1.66 ^{NS}	1.50 ^{NS}	1.41 ^{NS}	2.07 ^{NS}
MCH (pg)	Group 1	14.42 $\pm$ 0.57	14.94 $\pm$ 0.53	15.06 $\pm$ 0.38	14.98 $\pm$ 0.29
	Group 2	14.70 $\pm$ 0.34	14.22 $\pm$ 0.36	14.90 $\pm$ 0.31	14.96 $\pm$ 0.20
	T value	0.43 ^{NS}	1.12 ^{NS}	0.33 ^{NS}	0.06 ^{NS}
MCHC (%)	Group 1	31.60 $\pm$ 1.12	32.42 $\pm$ 1.13	32.24 $\pm$ 1.56	34.16 $\pm$ 1.33
	Group 2	29.30 $\pm$ 1.54	30.86 $\pm$ 1.54	30.62 $\pm$ 1.38	29.56 $\pm$ 1.36
	T value	1.21 ^{NS}	0.82 ^{NS}	0.78 ^{NS}	2.42 [*]

Note: *-significant at 5% level ($p < 0.05$).**-significant at 1% level ($p < 0.01$).

NS-non significant.

Biochemical parameters

There was a significant difference at recovery in ALT between the groups (Table-4). The lower value in group 1 might indicate low stress on liver induced by atracurium as compared to rocuronium as it is metabolized by Hoffman elimination which depends upon pH and temperature rather than hepatic pathways (Stenlake *et al.*, 1981 and Hughes, 1986). However, the total protein between the groups varied

significantly before drug administration, at recovery and at 24 hours of recovery between groups. Both groups differed at base values and at 24 hours of recovery which might nullify undesirable effects due to administration of these NB agents. The serum potassium and chloride level also varied significantly at recovery between the groups but it remained within normal limits.

Table 4: Effects of atracurium (Group 1) and rocuronium (Group 2) administration on serum biochemical parameters in buffaloes. Mean $\pm$ S.E.

Parameters	Groups	Before drug admn.	At 5 min.	At recovery	At 24 hrs. of recovery
Glucose (mg/dl)	Group 1	70.96 $\pm$ 5.13	121.26 $\pm$ 12.4	106.86 $\pm$ 13.91	75.36 $\pm$ 1.86
	Group 2	64.90 $\pm$ 4.65	128.54 $\pm$ 6.57	109.46 $\pm$ 4.60	70.60 $\pm$ 4.12
	T value	0.88 ^{NS}	0.52 ^{NS}	0.18 ^{NS}	1.05 ^{NS}
HDLc (mg/dl)	Group 1	38.98 $\pm$ 2.81	39.44 $\pm$ 3.32	39.36 $\pm$ 4.05	40.14 $\pm$ 3.85
	Group 2	43.70 $\pm$ 3.27	43.34 $\pm$ 3.08	39.72 $\pm$ 2.88	41.66 $\pm$ 2.95
	T value	1.09 ^{NS}	0.86 ^{NS}	0.72 ^{NS}	0.31 ^{NS}
LDLC (mg/dl)	Group 1	12.81 $\pm$ 2.23	12.08 $\pm$ 1.71	11.89 $\pm$ 1.64	12.15 $\pm$ 1.85
	Group 2	13.00 $\pm$ 1.54	16.56 $\pm$ 3.85	19.58 $\pm$ 4.85	16.84 $\pm$ 1.63
	T value	0.07 ^{NS}	1.06 ^{NS}	1.50 ^{NS}	1.90 ^{NS}
Total cholesterol (mg/dl)	Group 1	62.40 $\pm$ 2.46	65.80 $\pm$ 2.69	66.00 $\pm$ 2.85	61.20 $\pm$ 1.77
	Group 2	62.20 $\pm$ 2.60	65.40 $\pm$ 3.93	64.80 $\pm$ 4.35	64.00 $\pm$ 2.35
	T value	0.06 ^{NS}	0.08 ^{NS}	0.23 ^{NS}	0.95 ^{NS}
Triglycerides (mg/dl)	Group 1	15.58 $\pm$ 0.73	18.60 $\pm$ 0.65	16.56 $\pm$ 0.67	14.70 $\pm$ 0.82
	Group 2	12.38 $\pm$ 1.41	15.94 $\pm$ 1.06	17.58 $\pm$ 1.05	12.57 $\pm$ 1.46
	T value	2.01 ^{NS}	2.13 ^{NS}	0.82 ^{NS}	1.27 ^{NS}
Cortisol (ng/ml)	Group 1	28.98 $\pm$ 2.05	33.34 $\pm$ 3.37	30.33 $\pm$ 1.83	27.83 $\pm$ 2.61
	Group 2	27.73 $\pm$ 1.37	31.68 $\pm$ 3.50	29.37 $\pm$ 1.16	27.89 $\pm$ 0.70
	T value	0.51 ^{NS}	0.34 ^{NS}	0.30 ^{NS}	0.03 ^{NS}
LDH (IU/L)	Group 1	520.20 $\pm$ 42.86	527.40 $\pm$ 45.69	514.80 $\pm$ 47.48	525.20 $\pm$ 48.78
	Group 2	536.80 $\pm$ 58.14	530.00 $\pm$ 54.13	525.60 $\pm$ 48.95	528.80 $\pm$ 54.63
	T value	0.23 ^{NS}	0.03 ^{NS}	0.16 ^{NS}	0.05 ^{NS}
ALT (IU/L)	Group 1	29.82 $\pm$ 3.53	37.02 $\pm$ 1.64	36.02 $\pm$ 1.13	29.76 $\pm$ 0.32
	Group 2	29.58 $\pm$ 1.49	33.54 $\pm$ 1.72	31.66 $\pm$ 1.39	29.60 $\pm$ 1.35
	T value	0.06 ^{NS}	1.47 ^{NS}	2.43 [*]	0.12 ^{NS}
AST (IU/L)	Group 1	45.50 $\pm$ 1.55	47.04 $\pm$ 2.60	43.62 $\pm$ 3.13	42.70 $\pm$ 1.57
	Group 2	45.30 $\pm$ 3.56	47.92 $\pm$ 3.48	45.78 $\pm$ 2.88	44.40 $\pm$ 3.79
	T value	0.05 ^{NS}	0.20 ^{NS}	0.51 ^{NS}	0.42 ^{NS}
ALP (IU/L)	Group 1	85.20 $\pm$ 14.13	92.60 $\pm$ 15.27	91.80 $\pm$ 13.52	86.60 $\pm$ 11.10
	Group 2	94.80 $\pm$ 10.86	84.20 $\pm$ 11.32	81.80 $\pm$ 9.72	90.20 $\pm$ 7.36
	T value	0.54 ^{NS}	0.44 ^{NS}	0.60 ^{NS}	0.27 ^{NS}
GGT (IU/L)	Group 1	20.65 $\pm$ 1.07	22.57 $\pm$ 1.06	21.49 $\pm$ 1.07	21.28 $\pm$ 1.28
	Group 2	24.11 $\pm$ 1.71	25.28 $\pm$ 1.69	24.57 $\pm$ 1.80	23.22 $\pm$ 1.75
	T value	1.72 ^{NS}	1.36 ^{NS}	1.47 ^{NS}	0.89 ^{NS}
Total Bilirubin (mg/dl)	Group 1	0.17 $\pm$ 0.03	0.17 $\pm$ 0.03	0.23 $\pm$ 0.06	0.21 $\pm$ 0.07
	Group 2	0.18 $\pm$ 0.03	0.18 $\pm$ 0.03	0.21 $\pm$ 0.04	0.18 $\pm$ 0.03
	T value	0.28 ^{NS}	0.46 ^{NS}	0.33 ^{NS}	0.32 ^{NS}
Bilirubin Direct (mg/dl)	Group 1	0.10 $\pm$ 0.02	0.09 $\pm$ 0.01	0.12 $\pm$ 0.02	0.11 $\pm$ 0.01
	Group 2	0.12 $\pm$ 0.01	0.13 $\pm$ 0.02	0.14 $\pm$ 0.03	0.13 $\pm$ 0.02
	T value	1.02 ^{NS}	1.85 ^{NS}	0.55 ^{NS}	0.67 ^{NS}
Indirect Bilirubin (mg/dl)	Group 1	0.07 $\pm$ 0.03	0.07 $\pm$ 0.02	0.11 $\pm$ 0.05	0.09 $\pm$ 0.06
	Group 2	0.06 $\pm$ 0.01	0.05 $\pm$ 0.02	0.07 $\pm$ 0.03	0.06 $\pm$ 0.02
	T value	0.28 ^{NS}	0.64 ^{NS}	0.82 ^{NS}	0.55 ^{NS}
Total Protein (mg/dl)	Group 1	8.60 $\pm$ 0.18	7.77 $\pm$ 0.47	7.32 $\pm$ 0.19	8.53 $\pm$ 0.15
	Group 2	7.14 $\pm$ 0.41	6.62 $\pm$ 0.32	6.43 $\pm$ 0.33	7.45 $\pm$ 0.41
	T value	3.25 [*]	2.03 ^{NS}	2.23 ^{NS}	2.48 [*]
Albumin (mg/dl)	Group 1	3.03 $\pm$ 0.15	2.96 $\pm$ 0.08	3.16 $\pm$ 0.11	3.05 $\pm$ 0.06
	Group 2	2.88 $\pm$ 0.19	3.09 $\pm$ 0.27	2.98 $\pm$ 0.24	3.09 $\pm$ 0.20
	T value	0.63 ^{NS}	0.45 ^{NS}	0.67 ^{NS}	0.17 ^{NS}
Globulin (mg/dl)	Group 1	3.57 $\pm$ 0.20	3.81 $\pm$ 0.47	3.36 $\pm$ 0.17	3.48 $\pm$ 0.19
	Group 2	4.26 $\pm$ 0.34	3.53 $\pm$ 0.17	3.45 $\pm$ 0.14	4.36 $\pm$ 0.36
	T value	1.77 ^{NS}	0.56 ^{NS}	0.43 ^{NS}	2.15 ^{NS}
A:G	Group 1	0.86 $\pm$ 0.07	0.82 $\pm$ 0.08	0.89 $\pm$ 0.06	0.89 $\pm$ 0.06
	Group 2	0.69 $\pm$ 0.06	0.88 $\pm$ 0.08	0.860.06	0.73 $\pm$ 0.08
	T value	1.8 ^{NS}	0.56 ^{NS}	0.35 ^{NS}	1.66 ^{NS}
BUN (mg/dl)	Group 1	25.18 $\pm$ 6.61	23.02 $\pm$ 6.77	23.96 $\pm$ 7.25	25.52 $\pm$ 4.18
	Group 2	27.62 $\pm$ 1.54	29.62 $\pm$ 1.17	28.74 $\pm$ 1.24	26.74 $\pm$ 1.47
	T value	0.36 ^{NS}	0.96 ^{NS}	0.65 ^{NS}	0.28 ^{NS}
Creatinine (mg/dl)	Group 1	1.17 $\pm$ 0.04	1.14 $\pm$ 0.03	1.15 $\pm$ 0.04	1.11 $\pm$ 0.03
	Group 2	1.00 $\pm$ 0.21	1.16 $\pm$ 0.19	1.08 $\pm$ 0.20	1.11 $\pm$ 0.18
	T value	0.83 ^{NS}	0.10 ^{NS}	0.36 ^{NS}	0.01 ^{NS}
Sodium (mmol/L)	Group 1	138.46 $\pm$ 0.92	141.20 $\pm$ 0.93	140.42 $\pm$ 1.97	139.14 $\pm$ 1.60
	Group 2	143.12 $\pm$ 3.37	141.84 $\pm$ 3.67	144.02 $\pm$ 2.20	138.30 $\pm$ 2.90
	T value	1.33 ^{NS}	0.17 ^{NS}	1.22 ^{NS}	0.25 ^{NS}
Potassium (mmol/L)	Group 1	4.39 $\pm$ 0.33	5.91 $\pm$ 0.19	4.10 $\pm$ 0.15	4.48 $\pm$ 0.19
	Group 2	5.45 $\pm$ 0.40	6.43 $\pm$ 0.34	5.50 $\pm$ 0.20	5.01 $\pm$ 0.21
	T value	2.02 ^{NS}	1.32 ^{NS}	2.72 [*]	1.88 ^{NS}
Chloride (mmol/L)	Group 1	104.36 $\pm$ 1.67	102.76 $\pm$ 1.09	101.92 $\pm$ 2.81	105.44 $\pm$ 1.28
	Group 2	101.98 $\pm$ 3.44	105.72 $\pm$ 4.07	101.08 $\pm$ 3.55	98.36 $\pm$ 2.47
	T value	0.62 ^{NS}	0.70 ^{NS}	0.19 ^{NS}	2.55 [*]
Calcium (mg/dl)	Group 1	10.54 $\pm$ 0.27	11.24 $\pm$ 0.17	11.82 $\pm$ 0.21	10.24 $\pm$ 0.36
	Group 2	10.23 $\pm$ 0.43	11.44 $\pm$ 0.59	10.84 $\pm$ 0.41	10.57 $\pm$ 0.43
	T value	0.62 ^{NS}	0.32 ^{NS}	2.13 ^{NS}	0.6 ^{NS}
Phosphorous (mg/dl)	Group 1	6.30 $\pm$ 0.66	6.27 $\pm$ 0.49	6.20 $\pm$ 0.6	7.09 $\pm$ 0.47
	Group 2	5.55 $\pm$ 0.34	6.40 $\pm$ 0.19	6.33 $\pm$ 0.40	5.73 $\pm$ 0.07
	T value	1.01 ^{NS}	0.25 ^{NS}	0.18 ^{NS}	2.86 ^{NS}

Note: *-significant at 5% level ($p < 0.05$).**-significant at 1% level ($p < 0.01$).

NS-non significant.

Conclusion

Rocuronium was found to be better muscle relaxant than atracurium in terms of fast onset of action, shorter duration, rapid and smooth recovery and more cardiovascular stability in buffaloes.

Acknowledgement

The authors are thankful to Lala Lajpat Rai University of Veterinary and Animal Sciences, Hisar, Haryana for providing all facilities, resources and support required for this research.

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