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Research Article

Yarış Atlarında Halothan ve Sevofluran Anestezisinin Kardiyopulmoner Etkilerinin Karşılaştırılması

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Özet : Bu çalışmada; yarış atlarında halothan ve sevofluranın kardiyopulmoner etkileri karşılaştırılarak değerlendirildi. Yaşları 4-8 ağırlıkları 430±47 olan minör ortopedik cerrahi ve kastrasyon uygulanmış toplam 24 yarış atı çalışmanın materyalini oluşturdu. Halothan 14, sevofluran ise 10 ata uygulandı. Bütün atlar acepromazin ve xylazin hidroklorid ile premedike edildi. İndiksiyon ketamin hidroklorid ile sağlandı. Halothan grubunda inhalasyon anestezisi 8 L/dak O_2 ve %5 halothan ile başlandı daha sonra %6 ya, refleksler azaldığında %3-4 e kadar düşürüldü. Sevofluran grubunda 8 L/dak O_2 ve %8 sevofluran konsantrasyonu ile başlandı derin anestezide %3-4 e kadar düşürüldü. Nabız ve arteriyel kan basıncı monitörize edildi. Solunun sayısı inspeksiyon ile belirlendi. Alınan heparinize kanlardan pO_2, pCO_2 ve pH değerleri saptandı. Ölçüm zamanları 0. (baseline), 30., 60. ve 90. dakikalar olarak belirlendi. Her iki grubun anestezi protokollerinde komplikasyon gözlenmedi. Bütün olgularda bradikardi ve hipotansiyon saptanmadı. Solunum sayısı her iki grupta da düştü. Ancak sevofluran grubunda keskin düşüşler gözlendi ($p<0.001$). Sonuç olarak halothan ve sevofluranın atların inhalasyon anestezisinde kullanılabileceği, sevofluranın halothana göre daha fazla solunumu deprese ettiği ve anesteziden çıkışın sevofluran grubunda daha kısa olduğu belirlendi.

Anahtar kelimeler: Halothan, inhalasyon anestezisi, sevofluran, yarışatları

Comparison of Cardiopulmonary Effects of Halothane and Sevoflurane Anaesthesia in Racehorses

Summary : In this study, comparative effects of halothane and sevoflurane on cardiopulmonary system in racehorses were evaluated. A total of twenty-four racehorses, aged between 4 to 8 years, and weighed 430±47 kg were included in two-surgery groups; minor orthopaedic surgery or castration; of 24 horses, 14 were anaesthetized by halothane, and 10 were anaesthetized by sevoflurane. All horses were premedicated by acepromazine and xylazine hydrochloride. Ketamine hydrochloride was used for induction of anaesthesia. In halothane group, 5% halothane and 8 L/min of O_2 were applied for inhalation anaesthesia. Then it was maintained with 6% halothane and was reduced to 3 to 4% when reflexes were decreased. In sevoflurane group, 8% sevoflurane and 8 L/min of O_2 were applied for inhalation anaesthesia. Then it was reduced to 3 to 4% during the deep anaesthesia. Pulse and arterial blood pressure were followed. Respiratory rates were determined by inspection. Heparinized blood samples were collected for determination of pO_2, pCO_2 and pH at 0. (baseline), 30., 60., and 90. minutes of surgery. In both study groups, complications were not determined. None of horses had bradycardia or hypotension. Respiratory rates were decreased in both groups. Very sudden decrease of respiratory rate in sevoflurane group was determined $p<0.001$). In conclusion, either halothane or sevoflurane can be used in inhalation anaesthesia in horses; however, sevoflurane depressed respiratory rate more while shortened the recovery time compared to those in halothane.

Keywords: Halothane, inhalation anaesthesia, sevoflurane, racehorse

Introduction

General anaesthesia has been used for medical or surgical treatment in horses. In such cases, anaesthesia can be induced with injectable agents such as ketamine and xylazine or inhalant agents such as halothane or isoflurane (7). In recent years, there has been a growing interest in the use of sevoflurane for anaesthesia in horses (1, 7, 9, 12, 14).

It has been reported that all volatile anaesthetic agents cause dose-dependent cardiopulmonary depression, hypoventilation or hypotension at inspired concentrations required to provide a surgical plane of anaesthesia (13, 17).

Halothane, a commonly used volatile agent (2, 14, 17), is a potent myocardial depressant that decreases the cardiac output and tension depends on dosage. Halothane also decreases respiratory rate by depressing the respiratory centre (17).

Previous studies reported that sevoflurane a halogenated volatile anaesthetic agent characterized by a low blood-gas partition coefficient (0.6) with a minimum alveolar concentration (MAC) of 2.31 % in horses has benefits of rapid induction, providing deep anaesthesia, and rapid recovery (9, 11, 19, 20).

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Sevoflurane might be a safe anaesthetic for prolonged inhalation anaesthesia in horses (3, 6). However, several other studies reported that sevoflurane can cause dose-dependent cardiopulmonary depression as well as hypoventilation and hypotension during surgical anaesthesia (3, 6, 8, 15). Therefore, it was suggested that assisted or controlled ventilation and administration of an inotropic agent are required during anaesthesia with sevoflurane in horses (11).

Halothane and isoflurane have been well examined for their individual effects on the time-related changes of cardiovascular system in horses (4, 5, 10, 16). Very few studies compared sevoflurane with other inhalation anaesthetic agents in horses. In a study (18) comparing isoflurane and sevoflurane anaesthesia in horses, isoflurane was found more suitable for prolonged surgeries than sevoflurane. Comparative studies investigating the effects of halothane and sevoflurane anaesthesia on the time-related changes in cardiopulmonary system in horses are limited (6). The purpose of this study is to evaluate and to compare the effects of halothane and sevoflurane on cardiopulmonary system in the surgery of racehorses.

Materials and Methods

This study was carried out on horses that underwent minor orthopaedic surgery or castration in Jockey Club of Turkiye, Veliefendi Racecourse Equine Hospital. Twenty-four, Arabian breed (n=17) and Thoroughbred (n=7) horses, aged between 4 and 8 (6±2) years and weighed 430±47 kg were used in the study. Halothane anaesthesia was administrated to 14 horses and sevoflurane anaesthesia was administrated to 10 horses.

Anaesthetic protocol

Food was withheld for 12 hours before anaesthesia in all horses. A local anaesthetic solution (1 mL of 2% lidocaine) was injected SC over the jugular vein before catheters were inserted. A 14-gauge catheter was inserted into the left jugular vein to each horse for the administration of anaesthetic drugs and fluids during anaesthesia (10).

All horses were premedicated by IV injection of 0.03-mg/kg acepromazine (Vetranquil, 1% solution, Sanofi, France) (5), and then 30 minutes later 1.1 mg/kg xylazine hydrochloride (Xylaze 100 mg/ml, Bayer, Germany) was administrated via IV route. Induction was achieved by IV injection of 2.2-mg/kg ketamine hydrochloride (Alfamine 100 mg/ml, Ege Vet, Turkey) after 2 minutes of xylazine injection (9). Lactated Ringer's solution was infused at a rate of 3 mL/kg/h via a catheter positioned in the jugular vein (16).

After induction, all horses were gently restrained and intubated. Then horses were transported to padded surgery table and were connected to close system manual large animal anaesthesia equipment (Hofmann, Germany). They were positioned at dorsal or lateral recumbency. In halothane group, inhalation anaesthesia was started by 8 L/min of O_2 and at a concentration of 5% halothane (Fluothane 100 ml, Zeneca, U.K.) mixture. After 10 minutes, inhalation dose was maintained by 6% halothane, halothane concentration was reduced to 3 to 4 % when the reflexes diminished, and halothane concentration was reduced to 1 to 2 % when the horses were in deep anaesthesia with no reflexes.

In sevoflurane group, inhalation anaesthesia was started by 8 L/min of O_2 and at a concentration of 8% sevoflurane (Sevorane Likid 250 ml, Abbott, U.K.) mixture. Inhalation dose was maintained by reducing sevoflurane concentration to 3 to 4 % in deep anaesthesia. After completion of the sevoflurane inhalation, 1.1-mg/kg xylazine hydrochloride was administered via IV route in recovery box.

A total of 90 minutes of general anaesthesia was maintained by spontaneous respiration, whereas occasionally respiration was assisted using automatic ventilation equipment (Smith Respirator La-2100, Holland).

Monitoring

Heart rate (HR) and minimal arterial pressure (MAP) were monitorised from a. coccygea and recorded by a calibrated monitor (Sparelabs Medical 90367 USA) at 0. (baseline), 30., 60., and 90. minutes of surgery. Respiratory rate (RR) was inspected. Heart rate, MAP and RR were followed during the anaesthesia procedures. Dobutamine hydrochloride was kept ready just in case of hypotension.

Blood gases analysis

Heparinized blood samples were collected for analysis of blood gases (pO_2, pCO_2) and pH. Blood gases were determined by an analyser (Irma Blood Analysis System, USA) at 0., 30., 60., and 90. minutes of surgery.

Statistical Analysis

Data were analyzed by SPSS 10.0 version for Windows. The normality of the data was analyzed with Shapino-Wilk before the analysis of the data test. The variables except RR were normally distributed. The normally distributed variables were analyzed with the two way variance analysis of repeated measurements (GLM). The differences between two groups were determined with Mann Whitney U test and the differences between the repeated measurements were determined with the Friedman Repeated Measures Analysis of variance for the analysis of RR data. Data were expressed as means ± standard deviation (SD).

Results

The duration of operations in halothane and sevoflurane groups exceeded 90 min. in four and two cases, respectively. But measurements were stopped at 90. minute. No complications due to both anaesthesia protocols were observed in all animals. However, in sevoflurane group, 1.1-mg/kg xylazine hydrochloride was administrated after the completion of measurement and operations when the horses were still on surgery table and after cessation of anaesthetic agent for the transfer of the horses. In halothane group, this procedure was not needed.

Bradycardia and hypotension were not observed in all cases. No difference was determined between halothane and sevoflurane groups except the baseline values with respect to HR. In halothane and in sevoflurane groups, significant reductions ($p<0.001$) were determined at all sampling times in HR compare to the baseline value. Statistically significant differences were determined between two groups with regard to MAP values at 30., 60. $p<0.05$) and 90 min. ($p<0.01$). Compare to baseline levels, also MAP values were decreased in all sampling times with both anaesthetic agents ($p< 0.05$, $p<0.001$).

In sevoflurane anaesthesia, respiration was depressed in four cases, therefore respiration was assisted by automated ventilation equipment, and in the remaining six cases respiration was assisted by mechanic ventilation when necessary. Respiratory rate values were significantly lower ($p<0.001$) in sevoflurane group than halothane group in all sampling times except the baseline value. In both groups, RR values tended to decrease during the anaesthesia procedure, but a sharp decrease ($p<0.001$) was observed in RR values with the initiation of sevoflurane anaesthesia. In both groups, pO_2 values significantly increased ($p<0.001$), but there was no significant difference between two groups except baseline values. In pCO_2 values, a significant difference between two groups was found only in the measurements taken at 30. minutes ($p<0.05$). In halothane and sevoflurane anaesthesia, compare to baseline values, pCO_2 increased ($p<0.001$) at all sampling times. In both groups, pH remained within reference range during the anaesthesia procedures but differences were significant ($p<0.05$) between the groups at the measurements of 0. and 60. minutes (Table 1).

All horses in both groups were transfered to recovery box after the completion of the operations then extubated and observed for 15 minutes. No problem was observed during standing up after leaving the horses free.

Discussion and Conclusion

It has been reported that halothane is widely used for inhalation anaesthesia in horses for many years (7). However, the use of sevoflurane for inhalation anaesthesia in horses started in recent years (1, 7, 9, 12, 14), and similarities between sevoflurane and isoflurane were suggested by several researchers (1, 9, 11, 13, 14, 17).

It is well known that halothane is an anaesthetic agent, which depresses cardio-vasculary and respiratory systems (17). Previous studies also reported that sevoflurane causes hypoventilation and hypotension, thus affects the cardiopulmonary system in a dose dependent manner (1, 6). In the present study, in halothane group, no statistically significant differences were determined between the measurements during the anaesthesia procedure in HR in comparisons with the baseline values. In contrast, in sevoflurane group, significant decreases occurred in HR compare to baseline values, but no difference was determined between other measurements. However, the HR values remained within the physiological reference range in both groups. Similarly, although statistically significant decreases were observed in MAP values in both halothane and sevoflurane anaesthesia, the values were also within the physiological range. Although in previous studies (1, 6, 17), it was reported that both halothane and sevoflurane cause myocardial depression and hypotension, in the present study, remaining of both HR and MAP values within physiological range may suggest no cardio-vasculary depression at the doses used in this study. Significant differences found in MAP values at 30.,

Table 1. Cardiopulmonary parameters in halothane and sevoflurane anaesthesia in horses.

Cardiopulmonary Parameters	Study Groups	Time (min.) 0	30	60	90	p
HR (beats/min)	**Halothane**	31.7±3.4 ^{A}	31.5±3.6	30.6±13.2	30.1±3.3	p>0.05
	Sevoflorane	39.4±2.1 $^{a\,B}$	32.7±1.6 ^{b}	31.9±1.4 ^{b}	32.4±1.3 ^{b}	p<0.001
	P	p<0.001	p>0.05	p>0.05	p>0.05	
MAP (mmHg)	**Halothane**	98.6±8.5 ^{a}	78.7±8.5 ^{bA}	81.6±12 ^{bA}	80.6±8.4 ^{bA}	p<0.05
	Sevoflorane	90.2±3.4 ^{a}	72.3±5.0 ^{bB}	71.2±2.9 ^{bB}	72.0±2.2 ^{bB}	p<0.001
	P	p>0.05	p<0.05	p<0.05	p<0.01	
RR (bpm)	**Halothane**	(min-max)	(min-max)	(min-max)	(min-max)	p<0.001
	Sevoflorane	10 (8-12) ^{a}	6 (3-6) ^{bA}	6 (4-8) ^{bA}	7 (4-8) ^{bA}	p<0.001
	P	10 (8-12) ^{a}	4 (3-5) ^{bB}	4 (3-5) ^{bB}	4 (6-2) ^{bB}	
		p>0.05	p<0.001	p<0.001	p<0.001	
pO_2 (mmHg)	**Halothane**	86.4±4.4 ^{aA}	265.6±55.0 ^{b}	285.3±46.9 ^{b}	296.6±39.3 ^{b}	p<0.001
	Sevoflorane	81.7±3.7 ^{aB}	274.8±48.4 ^{b}	242.9±57.7 ^{b}	264.5±55.1 ^{b}	p<0.001
	P	p<0.01	p>0.05	p>0.05	p>0.05	
pCO_2 (mmHg)	**Halothane**	37.9±4.1 ^{a}	58.1±4.4 ^{b}	62.9±3.6 ^{b}	63.9±4.0 ^{b}	p<0.001
	Sevoflorane	40.6±2.2 ^{a}	62.6±3.3 ^{b}	61.1±4.0 ^{b}	62.2±2.5 ^{b}	p<0.001
	P	p>0.05	p<0.05	p>0.05	p>0.05	
pH	**Halothane**	7.39±0.18^{A}	7.39±0.14	7.39±0.18^{A}	7.39±0.19	p>0.05
	Sevoflorane	7.36±0.32^{B}	7.37±0.38	7.35±0.38^{B}	7.37±0.36	p>0.05
	P	p<0.05	p>0.05	p<0.05	p>0.05	

a-b: The values with different superscripts in the same row are different significantly.
A-B: The values with different superscripts in the same column are different significantly

60. and 90. minutes may result from the differences between baseline values in comparisons of the halothane and sevoflurane anaesthesia.

In previous studies, it was reported that halothane causes hypotension depending on the applied doses (2, 17) therefore inotropic agents such as dobutamine hydrochloride may be needed to prevent the development of hypotension (2). However, in the present study, dobutamine hydrochloride administration was not needed because of the lack of bradycardia and hypotension in all cases in both halothane and sevoflurane anaesthesia.

A significant difference was determined between halothane and sevoflurane anaesthesia with regard to RR. Furthermore, although, RR tended to decreases during the anaesthesia procedure in both groups, presence of a sharp decrease in RR values and occurrence of respiratory depression in 4 cases and diminished respiratory rate in the remaining 6 cases in sevoflurane anaesthesia confirmed that sevoflurane anaesthesia causes hypoventilation (1, 8, 9). Therefore, in the present study, in all cases in sevoflurane group, respiration was assisted or controlled as recommended previously (1, 6, 19). PO_2 values significantly changed in both halothane and sevoflurane anaesthesia which was not surprising. These changes were considered because of oxygen supply during anaesthesia procedures.

In this study, deep anaesthesia was obtained rapidly with both anaesthetic agents as indicated in many previous studies (1, 4, 6, 10, 20). However, recovery from the sevoflurane anaesthesia was more rapid (1, 8, 9) than halothane anaesthesia. Although, in sevoflurane group, 1.1-mg/kg xylazine hydrochloride, which was recommended in anaesthesia protocol (6) was administered to all horses following the observation of corneal reflexes to provide smoother standing, some of the animals still had problems in standing up. However, xylazine hydrochloride administration was not needed in halothane anaesthesia because of smooth standing up.

The results of this study have shown that halothane and sevoflurane can be used in inhalation anaesthesia of horses. However, since sevoflurane depresses respiration, and has shorter recovery time than halothane, pre-anaesthetic agents can be recommended in sevoflurane anaesthesia in horses to prevent post-anaesthetic complications.

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