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Evaluation of electrocardiogram changes in normovolemic hypotensive dogs treated with fluids alone or in combination with ephedrine or dobutamine

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Abstract

Normovolemic hypotension can occur due to vasodilation or loss of vascular tone sympathetic nervous system. The aim of the present study was to evaluate electrocardiographic changes and rhythm disorders in normotensive dogs with isoflurane-induced hypotension and treated with ephedrine, dobutamine and fluid therapy. Twenty-nine adult male and female dogs of Mixed breed, weighing 20.1 ± 4.3 kg and in the age range 1.5-2.5 years-old were selected. Anesthesia was induced and maintained with propofol and 1.5% isoflurane in 100% oxygen, respectively. Then, hypotension was induced by deep anesthesia provided with 3% isoflurane. The dogs were given one of five treatments of 1- Ringer's solution (1 ml/kg/min, n=5), 2- Ringer's solution (1 ml/kg/min) with intravenous administration of ephedrine (RE, 0.2 mg/kg, n=6, 3- Ringer's solution (1 ml/kg/min) with intravenous infusion of dobutamine (RD, 5 µg/kg/min, n=6), 4- Intravenous administration of ephedrine (E, 0.2 mg/kg, n=6) and 5- Intravenous infusion of dobutamine (D, 5 µg/kg/min, n=6). By the time the direct blood pressure reached above 60 mmHg after challenge, treatment was discountinued, and the amount of isoflurane was reduced. If there were no responses, the treatment was repeated once again. Electrocardiogram was obtained from all animals at defined time points. Heart rate after treatment was significantly higher in the ringer's with dobutamine (184.2 ± 14.75) than in ephedrine (99.6± 23.8) and dobutamine (108.8± 20/29). Heart rate in the ringers with ephedrine after treatment (110.5 ± 26.46) was significantly higher than the baseline. The changes in P wave, QRS, PR interval, QT, heart electrical axis, and ST segment shape were insignificant. It was concluded that the addition of ephedrine or dobutamine to conventional fluid therapy in normovolemic hypotensive dogs can be associated with higher heart rate values. According to the obtained results, dobutamine with ringer's solution increased the heart rate more than the other groups.

Key words: Hypotension, Dobutamine, Ephedrine, Electrocardiogram, Dog

Introduction

Hypotension occurs when the systolic and the mean arterial blood pressure become less than 80 and 60 mmHg, respectively. Early diagnosis of hypotension prevents the negative consequences, including insufficient tissue

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perfusion, renal, cerebral, and myocardial ischemia (Mazzaferro & Wagner, 2001). The most common cause of hypotension in animals is the loss of body fluids and a decrease in circulating blood volume (hypovolemia) (Haskins, 2012); however, other causes can lead to lower blood pressure as well (Klabunde, 2011).

Reduction of blood pressure without hypovolemia or normovolemic hypotension occurs in cases such as distributed shock (neurogenic, septic, anaphylactic), cardiogenic shock, spinal injuries, drug poisoning, electrolyte and acid-base disorders, and deep anesthesia (Secher and Van Lieshout, 2005; Guly et al, 2008; Summers et al, 2013; Silverstein and Hopper, 2014). The normovolemic hypotension can finally cause a substantial disturbance in oxygen supply to the tissues and even shock. If the animal does not receive emergency and effectual care, severe cellular hypoxia and organ damage will occur, and eventually, the animal may die (Laforcade and Silverstein, 2015).

Fluid therapy has considered the most effective way to improve the oxygen supply, maintain and restore blood pressure in hypotensive patients, and increase of cardiac output by improving preload (Davis, 2016). Various studies have shown that although fluid therapy is very effective in hypotensive patients, it is less effective or even ineffective in cases of normovolemic hypotension. In such cases, it is usually necessary to use certain drugs to manage blood pressure (Kudnig and Mama, 2002; Harold et al, 2013). Today, the intraosseous method is widely used in dogs for administration of drugs (Chitsaz et al, 2023; Gholami et al, 2025).

Ephedrine is a non-catecholamine sympathomimetic drug that directly or indirectly stimulates alpha and beta-adrenergic receptors (Hoffman, 2001; Plumb, 2018). It has positive inotrope effects, causes vasoconstriction, and increases the heart rate in bradycardia cases. It has also been used to treat anesthesia-induced hypotension (Ramsey, 2017).

Dobutamine is a potent alpha-1 adrenergic agonist with weak beta-1 and beta-2 adrenergic activities. Since most of the inotropic effects are related to increase cardiac alpha-1 activity, dobutamine, less than other adrenergic drugs, leads to tachycardia. Furthermore, it has no direct effect on vascular tone and resistance. Due to its inotropic effects, dobutamine primarily increases stroke volume and cardiac output in healthy animals. There is also a slight increase in heart rate, which has little contribution to the rise in cardiac output. An increase in cardiac output causes high blood pressure (Dubin et al, 2017).

According to the authors' knowledge, no study has investigated the simultaneous effects of fluid therapy and blood pressure-increasing drugs in hypotensive normovolemic dogs; therefore, this survey has aimed to compare ECG changes following either fluid therapy alone or combined with dobutamine and ephedrine in hypotensive normovolemic dogs.

Materials and methods

Before the study's begining, an ethical code (EE/1401.2.24.99424/scu.ac.ir) was obtained from the Research Ethical Committee of Shahid Chamran University of Ahvaz. Twenty-nine 1.5- to 2.5-year-old male and female dogs of Mixed breeds, weighing 20.1 ± 4.3 kg, were transferred to Veterinary Hospital and kept in separate cages for 2 weeks. Age detection was performed based on the dental formula and the amount of wear of the teeth. In the following, vaccines (hipradog + rabies) and anti-parasitic drugs (caniverm: 1 tablet per 10 kg) were given to them to eat. The studied dogs were collected from different parts of Ahvaz district through capture alive. Further, blood tests (CBC) and immunochromatography test were performed for *dirofilaria immitis*, and after ensuring the health of dogs, research was conducted on them. The dogs were

clinically healthy and in daily observations, none of them had any signs of liver, kidney, endocrine diseases. They were fed twice daily with free access to water. The animal health status was evaluated by performing a complete clinical examination and a CBC test. Their heart sounds, and blood pressure were normal before the experiment.

On the day of examination, the animals were transferred to the study place and kept for 30 minutes to adapt to the environment. Then the cephalic vein was catheterized with a suitable intravenous (IV) catheter. The dogs received 100% oxygen via a face mask for 5 minutes. Then, anesthesia was induced by administration of propofol (1%, Braun, Melsungen, Germany) titration. After intubation with an appropriate cuffed endotracheal tube, the dogs were placed in the right lateral recumbency and connected to a rebreathing anesthesia machine. Anesthesia was maintained by isoflurane (Forane, Abbott, Uk) in 100% oxygen. Mechanical ventilation was performed with a breathing rate of 8-10 times per minute and a vital volume of 10-15 ml/kg to maintain PaCO2 in the 35-45 mmHg range. Ringer's solution (Iranian Parenteral and Pharmaceutical Co., Tehran, Iran) was administered with a 3 ml/kg/h dose. Body temperature was attempted to maintain 37-38˚C using a blanket.

Under general anesthesia, the pedal artery was catheterized and connected to a direct blood pressure measuring device for continuous arterial blood pressure monitoring. The jugular vein was also catheterized with a central venous pressure measurement apparatus (Arrow International, PA, USA). An electrocardiogram (Digital ECG, Guangdong Biolight Meditech Co, BLT-1203 B, China) was taken continuously at a speed of 50 mm/second and a voltage of 10 mv.

The dogs were also connected to a multiparameter monitoring system (Burtons, PM-9000Vet, UK) to measure oxygen saturation of hemoglobin (SPO2), heart rate, non-invasive blood pressure (using a cuff at the metatarsal area), respiratory rate, rectal temperature, and end-tidal carbon dioxide (ETCO2).

After preparation, the dogs were maintained under general anesthesia with isoflurane 1.3% for 15 minutes. The data were recorded as time zero (Time 1). Then, the depth of anesthesia was increased using 3% isoflurane until the invasive arterial blood pressure reached below 60 mmHg and remained in this situation for 10 minutes (Chen et al, 2007). At this time, the data were measured and recorded (Time 2). The dogs were randomly divided into five groups and received one of five treatments: 1- Ringer's solution (1 ml/kg/min, R, n=5), 2- Ringer's solution (1 ml/kg/min) with intravenous administration of ephedrine (0.2 mg/kg; HBM Pharma s.r.o., Sklabinska martin, Slovak Republic) (RE, n=6), 3- Ringer's solution (1 ml/kg/min) with intravenous infusion of dobutamine (5 µg/kg/min; Hameln pharma gmbh inselstrabe, Hameln, Germany) (RD, n=6), 4- Intravenous administration of ephedrine (0.2 mg/kg, E, n=6) and 5- Intravenous infusion of dobutamine (5 µg/kg/min, D, n=6).

If, after treatment, the invasive blood pressure was reached over 60 mmHg and maintained for 15 minutes, the administration of drugs would discontinue, and the data would be recorded. Otherwise, the treatment would be repeated, and the data would be recorded 15 minutes later (Time 3). Then, within 15 minutes, the anesthesia was returned to isoflurane 1.3%, and the data would be recorded (Time 4). Afterward, the concentration of isoflurane was reduced to zero within 15 minutes, and the dogs recovered. In this investigation, ECG parameters were assessed including HR, heart rhythm, determination of the average of heart electrical axis, duration and amplitude of P and QRS waves, PR and QT intervals, and ST segment morphology.

Data were analyzed using GraphPad Prism 9 and Excel 2016 software. The

normal distribution of the data was checked and confirmed using the Fishers exact test. To compare the data of electrocardiogram changes, a Mix model (Repeated measure for ANOVA) and Bonferroni post hoc test were used to compare the data of electrocardiogram changes. Data are shown as mean ± standard deviation (SD). A level of $P< 0.05$ was considered significance.

Results

All dogs tolerated the anesthesia and hypotension processes well and were successfully recovered. No death or complications were seen related to the study's procedures until a follow-up of two weeks. Three dogs out of five in Ringer´s treatment, two dogs out of five in the dobutamine treatment, and one dog out of five in Ringer´s with Ephedrine, Ringer´s with dobutamine, and Ephedrine groups needed re-administration of therapy. One dog in Ringer´s, dobutamine, and dobutamine treatments did not show direct blood pressure above 60 mmHg after re-treatment. However, the blood pressure increased to 60 mmHg or more by reducing isoflurane concentration. In all dogs, after increasing the direct pressure to more than 60 mmHg, its decrease was not observed below 60 mmHg.

A comparison between treatments on heart rate showed that it was significantly higher in Ringer treatments with dobutamine and dobutamine alone ($p=0.0067$) than ephedrine alone ($p=0.0161$) at time 2. The within-group comparison showed that the heart rate in the Ringer´s with Ephedrine was significantly higher than the baseline at time 2 ($p=0.028$) (Table 1).

In most cases of electrocardiogram recording, the heart rhythm was sinus rhythm or sinus arrhythmia. The effects of time and group on the amplitude and duration of the P wave, QRS wave duration and ampitude, PR interval, QT interval, the heart electrical axis, and the shape of the ST segment were not significant ($P>0.05$). ST segment depression was not observed in any of the animals. ST elevation was seen in three dogs in Ringer´s with Ephedrine treatment at baseline, at times 1 and 2, and in four dogs at times 4 (Table 1). Wandering pacemaker and Sinus arrest were observed in the ringer´s and ephedrine treatments at time 4 in a dog (Figures 1 and 2).

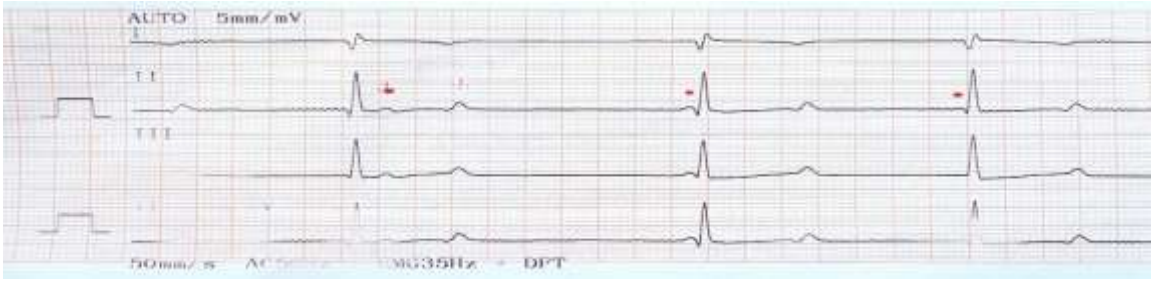

Figure 1: Wandering pacemaker in one of the dogs in group four that was received ephedrine alone

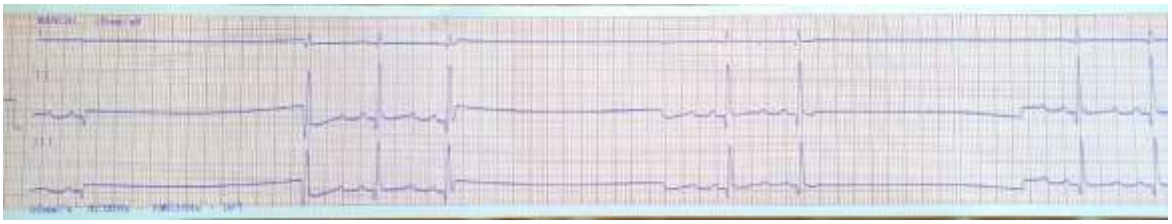

Figure 2: Sinus arrest in one of the dogs in group one that was received ringer solution alone

Table 1: Changes in electrocardiographic parameters in isoflurane-induced hypotensive dogs treated with 1- Ringer's solution (R), 2- Ringer's solution with intravenous administration (IV) of ephedrine (RE), 3- Ringer's solution with intravenous infusion of dobutamine (RD), 4- Intravenous administration of ephedrine (E) and 5- Intravenous infusion of dobutamine (D)

Parameters	Group	Baseline	Time 1 (hypotension induction)	Time 2 (treatment)	Time 4 (recovery)
Heart rate (beat/min)	R	23 ± 117	21 ± 101	20 [a] ±101	17 ± 105
	RE	13 ± 110	14 ± 88	26 [a] ±110	44 ± 126
	RD	28 ± 108	12 ± 92	15 [abA] ± 184	10 ± 119
	E	13 ± 113	18 ± 95	24 [ac] ± 100	38 ± 110
	D	32 ± 112	12 ± 107	20 [ac] ± 109	18 ± 114
P wave duration	R	0.03 ±0.01	0.04 ±0.01	0.04 ±0.00	0.04 ±0.01
	RE	0.04 ±0.00	0.04 ±0.00	0.04 ±0.00	0.04 ±0.00
	RD	0.04 ±0.00	0.04 ±0.00	0.04 ±0.00	0.04 ±0.00
	E	0.04 ±0.00	0.04 ±0.01	0.04 ±0.00	0.04 ±0.00
	D	0.03 ±0.01	0.04 ±0.01	0.04 ±0.00	0.04 ±0.01
P wave amplitude (mv)	R	0.18 ±0.06	0.23 ±0.07	0.21 ±0.06	0.23 ±0.04
	RE	0.20 ±0.09	0.16 ±0.08	0.20 ±0.07	0.25 ±0.07
	RD	0.21 ±0.05	0.19 ±0.07	0.21 ±0.07	0.21 ±0.02
	E	0.17 ±0.06	0.21 ±0.06	0.20 ±0.03	0.21 ±0.07
	D	0.16 ±0.05	0.16 ±0.06	0.20 ±0.02	0.18 ±0.04
QRS wave duration	R	0.04 ±0.00	0.04 ±0.01	0.05 ±0.00	0.04 ±0.01
	RE	0.04 ±0.00	0.04 ±0.00	0.05 ±0.00	0.05 ±0.00
	RD	0.05 ±0.00	0.05 ±0.00	0.05 ±0.00	0.05 ±0.00
	E	0.05 ±0.00	0.05 ±0.00	0.05 ±0.00	0.06 ±0.00
	D	0.04 ±0.01	0.05 ±0.00	0.05 ±0.00	0.05 ±0.01
QRS wave amplitude (mv)	R	1.45 ±0.75	1.70 ±0.53	1.42 ±0.99	1.47 ±0.43
	RE	1.14 ±0.26	0.78 ±0.39	1.06 ±0.16	0.90 ±0.48
	RD	1.16 ±0.65	1.20 ±0.48	1.52 ±0.42	1.24 ±0.47
	E	1.06 ±0.33	1.04 ±0.52	1.18 ±0.48	0.92 ±0.28
	D	0.97 ±0.50	0.78 ±0.58	0.85 ±0.65	0.88 ±0.70
PR duration	R	0.11 ±0.02	0.12 ±0.02	0.12 ±0.03	0.11 ±0.02
	RE	0.11 ±0.01	0.10 ±0.02	0.10 ±0.03	0.08 ±0.01
	RD	0.10 ±0.02	0.10 ±0.01	0.10 ±0.03	0.10 ±0.02
	E	0.09 ±0.02	0.10 ±0.00	0.10 ±0.01	0.06 ±0.03
	D	0.11 ±0.02	0.10 ±0.01	0.09 ±0.01	0.09 ±0.01
QT duration	R	0.24 ±0.04	0.24 ±0.02	0.25 ±0.03	0.24 ±0.05
	RE	0.27 ±0.03	0.26 ±0.03	0.26 ±0.04	0.23 ±0.05
	RD	0.25 ±0.04	0.25 ±0.01	0.25 ±0.04	0.24 ±0.01
	E	0.26 ±0.05	0.25 ±0.04	0.27 ±0.04	0.27 ±0.04
	D	0.23 ±0.03	0.23 ±0.02	0.24 ±0.04	0.24 ±0.02
Heart electrical axis (degree)	R	80.75 ±8.30	83.75 ±4.78	84.50 ±4.20	82.50 ±6.45
	RE	87.00 ±4.47	84.40 ±8.17	82.60 ± 7.50	79.40 ±10.81
	RD	79.00 ±12.45	76.40 ±18.01	81.40 ±10.24	76.80 ±17.80
	E	86.67 ±5.77	83.33 ±11.55	80.00 ±17.32	70.50 ±23.69
	D	68.83 ± 4.21	71.50 ±6.68	70.00 ±8.83	75.00 ±9.25

The different letters in each column indicate a significant difference ($P<0.05$).

Discussion

Various studies have shown that fluid therapy cannot alone restore normal pressure in cases of normovolemic hypotension in dogs. As a result, inotropes or vasoconstrictive have been tried to manage blood pressure (Kudnig and Mama, 2002; Harold et al, 2013). In cases of isoflurane-induced hypotension, as it decreases heart rate at high doses, myocardial contractile strength, peripheral vascular resistance, stroke volume, and cardiac output, so the reduction in isoflurane-induced compensatory responses has been proposed as the maintenance factor for the lack of response to the fluid infusion (Valverde et al, 2012; Yang et al, 2014). The current study evaluated the effect of ephedrine or dobutamine with fluid therapy on ECG parameters in managing the normovolemic hypotensive dogs induced by high doses of isoflurane.

In the present study, heart rate decreased slightly from the baseline compared with the time of hypotension induction in all groups, which was expected and directly related to the consequences of severe hypotension. After treatments, heart rate increased in ringer´s with dobutamine and ringer´s with ephedrine treatments; however, just heart rate in ringer´s with dobutamine was significantly higher than dobutamine and ephedrine alone treated dogs. Heart rate can be affected by the function of baroreceptors and respiratory cycle, as well as sympathetic and parasympathetic balance. Wagner et al, (1993) stated that ephedrine in both low and high doses increased blood pressure and decreased heart rate. Dubin et al, (2017) also reported that due to its inotropic effects, dobutamine primarily increases stroke volume and cardiac output and causes a slight heart rate rise. Goya et al, (2018), in a study on dogs, stated that the heart rate during anesthesia decreased with isoflurane and a low dose of dobutamine and increased with a high dose of dobutamine. Sousa et al, (2005) reported that heart rate increased in a dose-dependent manner with the increase in the dose of dobutamine, and at a dose of 10 μg/kg/min, it was not significantly different from the baseline. In the this study, it seems that the administration of dobutamine and ephedrine alone did not considerably change heart rate, which may be attributed to the ineffectiveness of used drugs to induce alterations in normovolemic hypotensive dogs. Interestingly, adding fluid therapy to ephedrine and dobutamine increased heart rate, highlighting the effect of increased preload in heart rate alterations; however, higher preload without supplemented drugs was ineffective in inducing heart rate changes, as we observed with ringer´s solution alone treatment.

Electrocardiogram measurements did not show significant differences among and within treatment's groups. The elevation of the ST segment observed in the ephedrine group can be caused by the increased catecholamines in the blood circulation and sympathetic stimulation by ephedrine (Adamson et al, 2004). The cause of deviations in the ST segment is caused by changes in the activity of the autonomic nerves of the coronary arteries or myocardium (Tilley and Smith, 2016). The most crucial reason for lowering this segment is myocardial ischemia and the rise of this segment in cases of myocardial hypoxia, in other words, lack of oxygen. This deviation was probably secondary to hypotension and did not indicate primary myocardial diseases.

In the current study, the changes in the P wave were insignificant between different times and treatments. As the amplitude and duration of P waves are considered normal up to 0.4 mv and 0.04 seconds in dogs, respectively (Nelson and Couto, 2019). The obtained results showed that the amplitude and duration of P waves were in this normal range. P wave indicates the depolarization of the right and left atria; therefore, it is an

indicator of the speed of transmission of electrical signals in the atria (Martin, 2015). Our results show that signal transmission speed does not seem to change significantly during hypotension in normovolemic dogs. Considering that P wave changes can occur in a rapid increase in heart rate, this finding can also indicate that the heart rate did not suddenly increase in this study.

The maximum duration of the QRS wave is 0.06 seconds, and the maximum amplitude of the QRS wave is three millivolts in large breed dogs (Nelson and Couto, 2019). Sousa et al, (2005) reported that P and QRS waves durations and amplitude did not change with increasing dosage f dobutamine. In all cases of electrocardiogram recording in this study, the duration and amplitude of the QRS waves were within their normal limits, so these changes were not significant at different times and among different treatment groups. The amplitude of the QRS fluctuated over time in all groups, but this difference was not statistically significant. Accordingly, hypotension and given treatments do not seem to cause a fundamental change in the speed of electrical signal transmission in the ventricles.

According to Tilley and Goodwin (2001), the shortening of the PR interval is caused by the conduction of the impulse through a secondary path to the AV node, and the lengthening of the PR interval is also a sign of first-degree AV block. In this study, in all cases of electrocardiogram recording, the PR interval was within the normal range of 0.06-0.13 seconds (Nelson and Couto, 2019). Tilley and Goodwin (2001) stated that variation in the size of the PR interval might occur with a change in the tonicity of the vagus nerve; the higher the HR, the shorter the PR interval and vice versa. The results of the present study are in line with the mentioned study, which can lead to the conclusion that electrical signal transmission in isoflurane-induced hypotension did not change significantly in the treated dogs.

Nelson and Couto (2019) reported that the normal QT interval was in the range of 0.15-0.25 and up to 0.27 seconds in dogs. The QT interval indicates the duration of depolarization and subsequent repolarization in the ventricles, and its changes are inversely related to heart rate. Autonomic nerve tone, drugs, and electrolyte disorders can cause changes in this interval. In all cases of electrocardiogram recording in this study, the QT intervals were within the normal range.

The mean of heart electrical axis indicates the general direction of the depolarizing electrical waves of the heart myocardium. In normal conditions and right lateral recumbency, where the left ventricle has an enormous volume of the myocardium, its expected value is between +40 and +100 degrees. Changes in the axis can be caused by how the animal is positioned, the difference in the chest structure, the presence of intraventricular conduction blocks, and the presence of structural heart diseases (Santilli et al, 2019). In the present study, the mean of heart electrical axis was within the normal range in all recorded cases. In conclusion, simultaneous use of fluid therapy and ephedrine or dobutamine can improve dogs' cardiovascular depressant effects of isoflurane-induced hypotension on heart rate. Dobutamine with ringer's solution increased the heart rate compared with ephedrine and other groups, due to positive inotropic effects.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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ارزیابی تغییرات الکتروکاردیوگرام در سگ‌های نرمولومیک دچار افت فشار خون، تحت درمان با مایع‌درمانی به تنهایی یا همراه با افدرین یا دوبوتامین

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چکیده

افت فشار خون نورموولمیک، می‌تواند به دلیل اتساع عروق یا از دست دادن تون عروقی سیستم عصبی سمپاتیک رخ دهد. هدف از انجام مطالعه حاضر، بررسی تغییرات الکتروکاردیوگرافی و اختلالات ریتم قلب در سگ‌های دارای فشار خون نرمال، مبتلا به افت فشار خون ناشی از ایزوفلوران، و تحت درمان با افدرین، دوبوتامین و مایع درمانی بود. بیست و نه قلاده سگ نر و ماده بالغ، از نژاد مخلوط، با وزن ۴/۳ ± ۲۰/۱ کیلوگرم و در محدوده سنی ۱/۵ تا ۲/۵ سال انتخاب شدند. بیهوشی به ترتیب با پروپوفول و ایزوفلوران ۱/۵ درصد، در اکسیژن ۱۰۰ درصد القاء و حفظ شد. سپس با بیهوشی عمیق ایزوفلوران ۳ درصد، افت فشار خون القا گردید. به سگ‌های تحت مطالعه، یکی از پنج درمان ۱- محلول رینگر (۱ سی‌سی/کیلوگرم در دقیقه، تعداد: ۵ سگ)، ۲- محلول رینگر (۱ سی‌سی/کیلوگرم در دقیقه) همراه با تزریق داخل وریدی افدرین (RE، ۰/۲ میلی‌گرم/کیلوگرم، تعداد: ۶ سگ)، ۳- محلول رینگر (۱ سی‌سی/کیلوگرم در دقیقه) با انفوزیون داخل وریدی دوبوتامین (RD، ۵ میکروگرم/کیلوگرم در دقیقه، تعداد: ۶ سگ)، ۴- تزریق داخل وریدی افدرین (E، ۰/۲ میلی-گرم/کیلوگرم، تعداد: ۶ سگ) و ۵- انفوزیون داخل وریدی دوبوتامین (D، ۵ میکروگرم/کیلوگرم در دقیقه، تعداد: ۶ سگ) داده شد. هر زمان که فشار خون مستقیم پس از درمان، به بالای ۶۰ میلی‌متر جیوه می‌رسید، درمان قطع می‌شد و مقدار ایزوفلوران کاهش می‌یافت. در صورت عدم پاسخ، درمان یک بار دیگر تکرار می‌گردید. الکتروکاردیوگرام از تمام حیوانات در مقاطع زمانی مشخص گرفته شد. تعداد ضربان قلب پس از درمان در گروه رینگر با دوبوتامین (۱۴/۷۵ ± ۱۸۴/۲) نسبت به افدرین (۲۳/۸ ± ۹۹/۶) و دوبوتامین (۲۰/۲۹ ± ۱۰۸/۸) به طور معنی‌داری بیش‌تر بود. تعداد ضربان قلب در گروه رینگر با افدرین پس از درمان (۲۶/۴۶ ± ۱۱۰/۵) به طور معنی‌داری بیش‌تر از سطح پایه بود. تغییرات در دامنه و دوره موج P، دامنه و دوره QRS، فاصله PR، فاصله QT، محور الکتریکی قلب و شکل قطعه ST معنی‌دار نبود. نتیجه‌گیری شد که افزودن افدرین یا دوبوتامین به مایع درمانی معمولی، در سگ‌های با افت فشار خون نورموولمیک، می‌تواند با تعداد ضربان قلب بالاتر، همراه باشد. با توجه به نتایج به دست آمده، دوبوتامین همراه با محلول رینگر (گروه ۳)، به میزان بیش‌تری، باعث افزایش تعداد ضربان قلب نسبت به گروه‌های دیگر شد.

کلمات کلیدی: افت فشار خون، دوبوتامین، افدرین، الکتروکاردیوگرام، سگ

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