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Original Research

Effects of Jugular Vein Occlusion on Cardiovascular Parameters in Horses During Exercise on a Treadmill

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ABSTRACT

The purpose of the present investigation was to examine the effects of unilateral and bilateral jugular vein occlusion by temporary surgical ligature on the heart rate and arterial and venous blood pressure in sedentary horses during progressive treadmill exercise. Six horses performed three exercise tests (ET). ET1, considered the control, was performed in horses without jugular occlusions. ET2 and ET3 were performed with unilateral and bilateral occlusion by temporary surgical ligature of the jugular veins, respectively. Heart rate, arterial pressure, and pressure of the occluded jugular vein were evaluated. Clinically, the horses presented apathy, head edema, congested mucous membranes, increased capillary refill time, and dysphagia. These signs were observed with the unilateral jugular vein occlusion and became more evident with the bilateral occlusion. Comparing ETs, no differences were observed in heart rate. However, jugular occlusions promoted a decrease in the mean arterial pressure and a severe increase in jugular pressure. Head edema caused by the jugular vein occlusion in the horses could interfere with the autonomic cardiovascular regulation of arterial blood pressure during exercise, likely leading to an impairment of tissue perfusion. Jugular occlusion, even unilateral, also causes severe head venous congestion, leading to venous hypertension that was aggravated by exercise, which could risk development of cerebral edema and neurological damage. The present results obtained from sedentary horses are preliminary data that lead us to suggest that sport horses presenting jugular occlusive thrombophlebitis, even unilateral, may be prevented from performing athletic activities.

1. Introduction

Thrombophlebitis affects the jugular veins in horses because these veins are the most commonly used sites to access venous circulation. The disease is associated with poor venipuncture technique, prolonged or improper placement of indwelling catheters, and injections of irritating drugs that lead to a mechanical or chemical injury of the vessel wall [1-8]. The clotting mechanism in horses is known to differ from that in humans, mainly reflected in a considerably shorter clotting time due to a great tendency for red blood cell aggregation [9]. Therefore, it may be presumed that such differences in clotting profile affect the reaction of the organism to catheter types and/or materials.

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Once jugular thrombophlebitis develops, blood flow is impaired due to a reduction in the vascular lumen by partial or complete thrombus occlusion [10]. This thrombus may evolve into complete recanalization of the vein, thrombus fibrous organization without recanalization or collateral circulation [7,11,12]. If the jugular thrombotic occlusion persists and collateral vascularization does not occur, especially when both jugular veins are involved, the resulting dysphagia and dyspnea due to the impaired venous return of the head will likely limit athletic performance [4,10,13].

To ensure a proper perfusion of active muscles during exercise, the cardiovascular system must maintain the blood pressure within narrow limits. Neural (sympathetic stimulation) and endocrine (release of catecholamines, activation of the renin-angiotensin-aldosterone system and stimulation of vasopressin release) mechanisms are activated to maintain vascular tone by preserving the blood volume [14]. In the athletic horse, this ability is well developed, and, due to increments in heart rate (HR) and arterial pressure, the cardiac output resting value may be eightfold increased during maximal exercise [15,16]. Therefore, cardiovascular regulation during physical exercise is characterized by transitory adjustments that are considered similar in trained and untrained individuals and could change as a consequence of the conditioning of the cardiovascular system in response to training [17,18]. However, many cardiovascular disorders are known to result in hemodynamic disarrangements that can interfere with this adaptive response and result in inadequate tissue perfusion.

Exercise and training are known to have considerable effects on mechanisms of blood coagulation in horses, leading to increased platelet aggregation and increased fibrinolytic activity [19-21]. However, the few studies that have been conducted in horses demonstrating coagulation parameter shifts due to exercise performance did not evaluate horses presenting thrombotic diseases as jugular thrombophlebitis.

In an attempt to correlate the presence of jugular thrombophlebitis in horses with their athletic performance, Moreau and Lavoie [7] examined the records of horses that presented the disease during their athletic lifespan. The authors suggested that thrombophlebitis did not affect the performance of horses used for leisure riding and other nonracing activities, even when the horses suffered from bilateral occlusion. However, thrombophlebitis in racing Standardbred horses was associated with a decreased chance of returning to racing. The retrospective study by Moreau and Lavoie [7] is the only report comparing the presence of jugular occlusion with performance in horses. Thus, the hemodynamic parameters in exercising horses presenting jugular vein occlusion have never been studied. Based on the hypothesis that head venous congestion due to the stoppage of jugular vein blood flow could modify cardiovascular dynamics during exercise, the purpose of the present investigation was to examine the effects of unilateral and bilateral jugular vein occlusion by temporary surgical ligature on the heart rate and blood pressure in sedentary horses during progressive exercise on a high-speed treadmill, aiming to understand the same effects in the athletic horse presenting jugular thrombophlebitis.

2. Materials and Methods

2.1. Horses and Study Design

Research trials were performed with six sedentary mixed breed adult horses, three geldings, and three mares with a mean age of 6 ± 1 years and a mean body weight of 344 ± 12 kg. All horses were considered healthy based on physical examination and blood count (PocH-100iV Diff; Sysmex, Brazil). During the experimental period, horses were housed in individual stalls and consistently fed concentrated pelleted feed and hay (*Cynodon dactylon*), twice a day with 12-hour intervals. Water was provided ad *libitum*. The six horses performed three sessions of an incremental exercise test (ET) on a high-speed treadmill (Galloper; Sahinco, Palmital, Brazil) housed in an air-conditioned laboratory set at 25°C, with a 24-hour interval between sessions. The first test (ET1), considered the control, was performed in horses without jugular vein occlusion. The second (ET2) and third (ET3) tests were performed in horses with occlusion by ligature of the left jugular vein and with occlusion of both jugular veins, respectively. All experimental protocols performed in the current study were approved and supervised by the institutional committee on animal research and ethics (protocol no. 004302-06).

2.2. Treadmill Exercise Protocols

One week before the exercise tests, the horses were acclimated to the treadmill over 3 days. On the first day, they were led onto and stopped on the equipment several times to acquaint them with the room, rubber floor, and side and front safety bars. After they adjusted to this procedure, they were fitted with a safety belt, walked (1.5 m/s) on the treadmill for 5 minutes and then stopped. This procedure was repeated three times. On the second day, the horses were led onto the equipment, walked (1.5 m/s) for 5 minutes and trotted (3.5 m/s, 4.5 m/s, and 5.5 m/s) for 3 min at each speed. Some horses adjusted quickly to the treadmill and could be cantered (6.5 m/s, 7.5 m/s, and 8.5 m/s) for 2 min at each speed on the same day. On the third day, the procedure was repeated, with all horses being walked, trotted, and cantered.

The total duration of each ET was 83 min, including 18 min of incremental exercise, rigorously timed according to a predetermined rest and exercise sequence (Table 1). The proposed exercise test could be considered medium intensity. Finally, the horses cooled down with 5 min of trotting and 10 min of walking, followed by 30 minutes of recovery at rest. The entire test was performed on a level surface. The cardiovascular variables were recorded at 13 time points (T). The first evaluation (T0) was performed at rest at the last 30 seconds before the start of the exercise. During exercise, measurements were taken at the last 30 seconds before each speed change (T1-T10). During the recovery phase, two measurements were taken at rest 15 minutes (T11) and 30 minutes (T12) after the end of the exercise.