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Original Research

Evaluation of Overground Endoscopy Findings in Sport and Pleasure Horses

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ABSTRACT

Any factors that increase negative pressure in the upper respiratory tract (URT) can influence its mechanics. The aim of this report was to describe the results of URT diagnostic evaluation with overground endoscopy in sport and pleasure horses. The URT and plasma lactate levels were evaluated during rest and during overground endoscopic examination in 19 cases. Horses performed their normal training session. When history and clinical examination suggested a lower airway obstruction, we performed bronchoalveolar lavage. Dorsal displacement of the soft palate (DDSP) was diagnosed in 8 of 19 horses, which might have developed secondary to URT or lower respiratory tract inflammation or obstruction. DDSP was also detected at rest in four cases. Laryngeal hemiplegia (LHP) was diagnosed in 15 of 19 horses, 11 of which were complex cases with other types of URT obstructions. Severe pharyngeal collapse (PHC), suspected already at rest, was visible in two cases during exercise. In contrast, PHC diagnosed with nasal occlusion at rest in two cases was fully compensated under the rider. Plasma lactate levels significantly decreased during exercise. All DDSP cases were suspected to be of inflammatory or obstructive origin, which is different from findings in racehorses, where extrinsic causes are more common. Resting endoscopic examinations were sensitive in cases of obstructive origin. LHP and PHC could not be predicted on the basis of findings at rest, and increased neuromuscular activity during exercise could compensate for the problem in less severe cases. Decreased levels of lactate could be explained by the increased clearance during exercise.

1. Introduction

Dynamic upper respiratory tract (URT) obstruction is a common cause of abnormal airway noise and exercise intolerance in equine athletes. Several previous studies have documented that these disorders are underestimated or cannot be diagnosed during a resting endoscopic examination. To establish a definitive diagnosis of URT obstruction, exercising videoendoscopy is regarded as the "gold standard" method [1]. In the past 25 years, high-speed treadmill endoscopy made it possible to evaluate the dynamic collapse of the URT [2]. More recently, the advent of overground endoscopy (OE) has allowed the monitoring of upper airway behavior in normal exercising conditions, during ridden or driven exercise in the field [3].

Horses—contrary to human beings—are obligate nasal breathers. They can only decrease the air resistance by contracting the musculature of the URT [4].

During inspiration, when the diaphragm contracts, negative pressure develops in the URT and the lower respiratory tract (LRT). Airflow volume is substantially increased during exercise, which results in increased negative pressure. The nasopharynx and the larynx have a tendency to collapse, because neither of them has a bony and/or stiff structure, and active muscle work is needed to prevent

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this [5]. If the respiratory tract is obstructed, vortices causing abnormal respiratory noise may develop [6].

Any factors that increase negative pressure in the URT, for example poll flexion, increased pressure in the LRT or multiple obstructions [7], or constitutional changes [8], can markedly influence the mechanics of the URT. When evaluating the URT, we also have to consider possible causes of nasopharyngeal instability, such as an immature nasopharynx or inflammation of the URT and/or LRT. Although it is true that dynamic functional disease of the URT can be diagnosed via exercising endoscopy, resting endoscopy can predict certain diseases, provide information for understanding the causes of some functional changes, and it plays an important role in the detection of structural and/or morphologic deformations.

Reports of dynamic airway obstructions are primarily concerned with racehorse populations, whereas reports on such obstructions in sport horses are scarce [9].

Van Erck-Westergren [10] evaluated the effect of head flexion, riding, and airway inflammation in sport horses. For further investigation of this topic, the present report documents 19 cases of dynamic URT obstructions using OE. The aim of this report was to describe the results of URT diagnostic evaluation with OE in sport and pleasure horses.

2. Material and Methods

The study was restricted to sport (national level) and pleasure horses referred for OE with a history of poor performance and/or abnormal respiratory noise. Nineteen horses—16 warmbloods and three ponies—were examined, ranging in age from four to 21 years (10.6 ± 4.7). Seven horses were pleasure horses, five were competing in dressage, and seven were show jumpers. After recording the medical history and performing a physical examination, all horses underwent a resting and OE performed with dynamic respiratory scope (Optomed, DR v3, Les Ulis, France) saddle pad version. The scope was passed from one of the nostrils; to handle the horse, a nose twitch was applied, and no sedatives were used.

Resting endoscopic examinations were done immediately before the exercising tests. The morphology and function of the larynx and pharynx were evaluated, and occlusion test was performed to induce URT obstruction.

Overground endoscopy was done in an outdoor court. The horses were ridden by their usual riders, who were instructed to exercise the horses as usual during OE, according to the level and discipline of the horses. The riders were asked to ride the horses with loose reins and also in poll flexion at each gate. Horses were ridden until fatigue or until it became evident which URT functional disease was causing the poor performance or abnormal respiratory sound. The time when the functional change became most evident was documented, and it was determined whether it was constantly present. During the evaluation of the URT, the following data were documented (Table 1).

When the history, the physical examination, and the clinical signs revealed a significant LRT obstruction, bronchoalveolar lavage (BAL) was performed. When inflammation with infectious origin was suspected, culturing of the tracheal lavage was performed. Tracheal sampling can both reflect the URT and the LRT disorders. When bacteriology samples from the tracheal lavage were positive and there were also endoscopic signs of URT inflammation (lymphoid hyperplasia, red mucosal membranes, and increased amount of mucus in the nasopharynx) and no signs of LRT infection appeared (no alteration on endoscopy of the trachea and main bronchi), then URT inflammation was suspected. For a definitive elimination of the involvement of LRT, BAL cytology should have been performed in these cases. It is the weakness of this report that results are based on findings in clinical cases, where only necessary diagnostic methods could have been performed because of the owner's financial constraints.

Fisher exact test was used to search for the likeliness of the coincidence of URT–LRT obstructions.

Four blood samples were collected to measure plasma lactate levels. 0: blood sample at rest in the box, before the exercise; 1: blood sample during exercise, after the warm-up session; 2: blood sample during exercise, after the most

Table 1
Disorders during resting and overground endoscopy.

Disorders	Resting Endoscopy	Overground Endoscopy
Morphologic changes	Yes/no	—
Lymphoid hyperplasia	I–IV	—
Nasopharyngeal mucus	−, +, ++,	−, +, ++,
PI	−, +, ++,	−, +, ++,
Pharyngeal collapse	−, +, ++, lateral/dorsal/circumferential	−, +, ++, lateral/dorsal/circumferential
DDSP	Yes/no	Yes/no
LHP	I, II/1, II/2, III/1, III/2, III/3, IV (Havemeyer grading system)[a]	—
ACC	—	A, B, C[a]
VCC	—	A, B, C
RDPA	—	Yes/no
ADAF	—	Yes/no
When was the FD the most relevant?	▪ Occlusion test ▪ Constantly appearing ▪ No FD	▪ Low/high intensity work ▪ Loose reins ▪ Poll flexion and low intensity work ▪ Poll flexion and high intensity work ▪ At fatigue ▪ Constantly appearing

Abbreviations: ACC, arytenoid cartilage collapse; ADAF, axial deviation of the aryepiglottic fold; DDSP, dorsal displacement of the soft palate; FD, functional disease; LHP, laryngeal hemiplegia; PI, palatal instability; RDPA, rostral displacement of the palatopharyngeal arch; VCC, vocal cord collapse.
[a] [11].

intensive workload; and 3: blood sample in stall rest (approximately 1 hour) after work.

Blood samples were taken from the jugular vein into vacuum collecting tubes containing sodium fluoride. All samples were carried to the laboratory in a 4°C cooling bag within 4 hours after sampling, where the tubes were immediately centrifuged (10 minutes, 4,000g). After separation, plasma lactate levels were analyzed (Olympus AU/640, Japan, Tokyo).

Sample averages of the lactate level intervals were calculated with a one-sample *t* test at 0.95 confidence levels. Paired sample *t* test was used to compare the averages.

3. Results

This is a retrospective evaluation of the findings from the dynamic endoscopic examinations of 19 sport and pleasure horses. The majority (15 of 19) had left laryngeal hemiplegia (LHP) with or without the presence of one or more other abnormalities. Dorsal displacement of the soft palate (DDSP) was the second most common finding. As a first classification of URT functional disease, it was determined whether simple or multiple obstructions were visible during OE. Cases in which arytenoid cartilage collapse (ACC) and vocal cord collapse (VCC) occurred simultaneously or palatal instability (PI) appeared before DDSP were considered as simple cases. All other combinations of URT obstructions were regarded as complex cases.

Considering the whole endoscopic examination (resting endoscopy and OE), 7 of 19 simple and 12 of 19 complex cases were observed. Eight of 19 horses had DDSP, including two simple and six complex cases. One of eight developed DDSP only at rest, whereas among the seven cases where DDSP appeared during exercise, DDSP could be detected at rest in four cases. All the horses were coughing simultaneously with the displacement (>70%, binomial test with $P = .05$) and all but one performed poorly. Abnormal respiratory sounds were detected only in the complex cases and were secondary to URT functional diseases other than DDSP. Regarding the origin of DDSP, in two cases, it might have developed secondary to neuromuscular weakness caused by a suspected URT inflammation and six were most likely due to LRT obstruction, where inflammatory airway disease (IAD) or recurrent airway obstruction (RAO) was confirmed on the basis of BAL cytology. Other reasons such as constitutional problems or immature nasopharynx are unlikely to be predisposing factors of DDSP in our cases, as it is described later in the text.

Severe (++) PI was detected in nine cases; we observed that LRT obstruction and PI typically occurred simultaneously (Table 2) in our population, and their dependence was verified by Fisher exact test ($P = .001$).

Fifteen of 19 cases showed some degree of left LHP, 4 of 15 were simple, 11 of 15 were complex cases where pharyngeal collapse (PHC), DDSP, PI, or rostral displacement of the palatopharyngeal arch occurred besides LHP (Fig. 1). All horses with grade III/2 or IV LHP (seven horses) emitted abnormal inspiratory sounds during training; four of these horses showed poor performance according to their owners. In lower grades (II/1, II/2), abnormal respiratory noise and poor performance appeared secondary to other URT and/or LRT obstructions. Of the nine horses with grade II or III LHP, three were classified as grade A during exercise and six animals developed ACC and VCC when ridden. In one case, where full abduction was visible at rest, grade B, bilateral ACC and VCC were observed during poll flexion. In five cases, grade 4 LHP was detected at rest; besides grade C ACC at exercise, we documented grade C VCC in all cases which were either unilateral, bilateral, ipsilateral, or contralateral. All cases with LHP were idiopathic except one, where distal axonopathy developed secondary to a paravenous injection administered to the left jugular area. In two cases, besides LHP, exercise-induced pulmonary hemorrhage (EIPH) was proven by the presence of hemosiderophages on BAL fluid cytology. In one of the cases, IAD was also confirmed simultaneously with EIPH.

Interestingly, besides PI, grade B ACC and VCC occurred in two ponies. These ponies were performing poorly and had LRT obstructions (IAD).

In six cases, PHC was detected. During exercise, severe PHC was visible in two cases, which could be suspected already at rest. In contrast, in two cases of PHC diagnosed with nasal occlusion at rest, the problem was fully compensated through neuromuscular activity when ridden. In the remaining two cases, mild PHC was only visible during exercise and could not be induced by occlusion test at rest. Abnormal respiratory sounds were obvious in all the severe cases and in one of the mild cases. PHC typically exacerbated during poll flexion (Fig. 2). The

Table 2
Relationship of LRT obstruction and palatal instability.

LRT Obstruction	PI Was Observed (n)	PI Was Not Observed (n)
LRT obstruction	8	1
No LRT obstruction	1	9

Abbreviations: LRT, lower respiratory tract; PI, palatal instability.

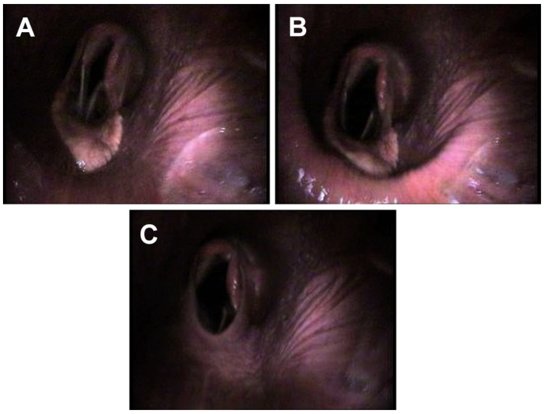

Fig. 1. Complex case. Overground endoscopy image from case 1, showing arytenoid cartilage collapse, vocal cord collapse, flat epiglottis (A), palatal instability before dorsal displacement of the soft palate (B), and dorsal displacement of the soft plate (C).

Fig. 2. Dorsal pharyngeal collapse. Upper airway endoscopy of case 16 during poll flexion, dynamic collapse of the dorsal pharyngeal wall is visible.

soft palate was more instable when the rider gathered the horse. The degree of bilateral ACC severely increased during poll flexion in one case (Fig. 3).

The complexity of the cases is illustrated in Figs. 4 and 5.

Sample averages of the lactate levels are presented in Table 3 (intervals calculated with a one-sample t test at 0.95 confidence levels). Using a paired sample t test, it was confirmed that the values measured during rest (0) are significantly higher than those measured during exercise (1 and 2). The application of this method was justified by the high correlation coefficients ($\sim$0.8 in both cases). When calculated at 0.95 confidence level, the difference between the values at 0 and 1 were 0.44 ± 0.16 mmol/L and between the values at 0 and 3 were 0.32 ± 0.16 mmol/L.

4. Discussion

As it has been described in previous studies, DDSP can be attributed to different causes, and its treatment has to be adjusted accordingly [12]. In the literature, these causes are often divided into two groups depending on whether they are related to the intrinsic muscles (palatinus and palatopharyngeus muscles) [13] or to the extrinsic palatal musculature (thyrohyoid muscle) [9]. Intrinsic causes may involve neuromuscular weakness (e.g., URT infection) or structural deformations (subepiglottic cysts, granuloma, epiglottitis, epiglottic chondritis, and so forth) in the pharynx [13,14]. DDSP that is suspected to develop secondary to neuromuscular weakness because of URT infections should be treated conservatively, with local or

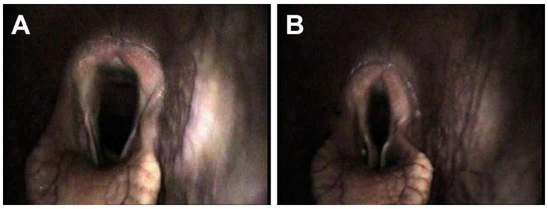

Fig. 3. Bilateral dynamic laryngeal collapse. Endoscopy image obtained from case 12 showing full abduction of the arytenoid while the horse is ridden with extended neck (A) and poll flexion induced, bilateral arytenoid cartilage collapse, and unilateral axial deviation of the aryepiglottic fold (B).

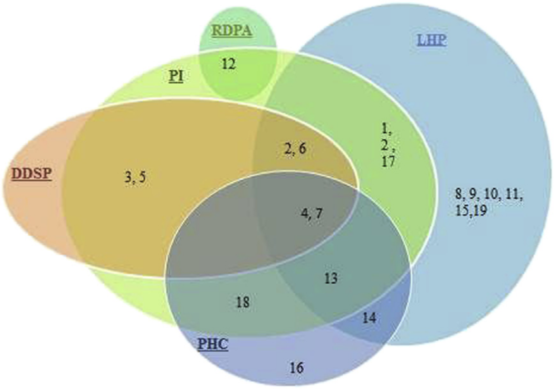

Fig. 4. Results of resting endoscopic examination. The numbers are reflecting the cases. DDSP, dorsal displacement of the soft palate; LHP, laryngeal hemiplegia; PI, palatal instability; PHC, pharyngeal collapse; RDPA, rostral displacement of the palatopharyngeal arch.

systemic anti-inflammatory and antibiotic therapy. These cases are more prone to DDSP subsequent to the more negative pressures of increased respiratory effort because of the neuromuscular weakness. Structural deformations usually need surgical intervention [12]. DDSP is an URT obstruction typical for Thoroughbreds, which usually occurs during high-intensity exercise. In this case, the extrinsic cause is thought to be the relative position of the larynx, excessively caudal, and ventral to the basihyoid and the soft palate [15]. The reason why it is so common in racehorses might be that at high galloping speed, there is a higher chance of development of DDSP, due to the increased activity of the muscles that affect the interrelationships between the larynx, the pharynx, and the hyoid apparatus [16]. In such cases of extrinsic origin, tie forward surgery is the suggested choice of treatment [17]. The success rate of this surgery is 68% to 90%, so there is a nonnegligible chance of failure in general [12]. However, in racehorses, another explanation of unsuccessful tie forward surgery could be that the immature nasopharynx of a

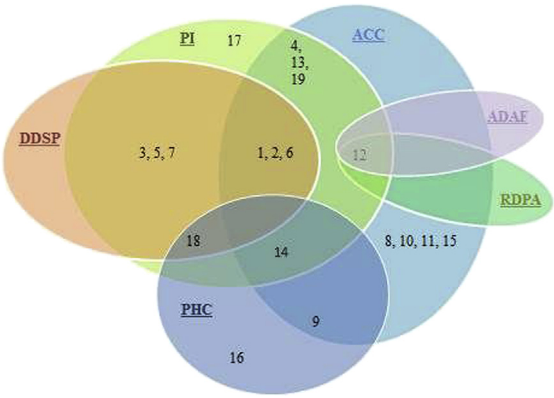

Fig. 5. Results of dynamic URT obstructions during overground endoscopy. The numbers are reflecting the cases. ACC, arytenoid cartilage collapse; ADAF, axial deviation of the aryepiglottic fold; DDSP, dorsal displacement of the soft palate; PI, palatal instability; PHC, pharyngeal collapse; RDPA, rostral displacement of the palatopharyngeal arch; URT, upper respiratory tract.

Table 3
Plasma lactate levels.

Rest/Exercise	Lactate levels
0. Rest (before exercise)	0.93 ± 0.21 mmol/L
1. Exercise (after warm-up session)	0.48 ± 0.08 mmol/L
2. Exercise (after intensive workload)	0.54 ± 0.19 mmol/L
3. Rest (after exercise)	0.75 ± 0.2 mmol/L

young Thoroughbred, which is an intrinsic cause, can lead to the appearance of DDSP, which can be resolved by resting the horse until the nasopharynx matures. This solution might not be feasible for many gallop horses, since the period while they can compete at top level is quite short. This raises the issue whether the immature nasopharynx might be stabilized by sclerotherapy [18] of the soft palate with a diode laser rather than by a tie forward surgery. Immature nasopharynx is not a substantive problem in our population of sport and pleasure horses because of the older age of our cases compared with racehorses.

Negative pressure and inspiratory airflow increase in all cases of exercise, even with the low-to-moderate levels involved in this report. What varies from case to case, with respect to DDSP, is the magnitude of the increase that is required to induce the displacement in a given horse. We propose that DDSP caused by severe LRT obstruction (RAO) is common among the sport and pleasure horses examined in the present study. In these cases, the markedly increasing negative pressure driven by the LRT obstruction might lead to a simultaneous negative pressure increase in the URT resulting in a DDSP. Implicitly, we suggest a primary treatment of the lower airways in these cases. In one case, a less severe URT obstruction (IAD) was suspected to cause palatal dysfunction. In this case, DDSP occurred only at resting endoscopy, during exercise there was only PI visible. The pathomechanism of this might be explained by the following. A good indication of how sympathetic and/or adrenergic drive can overcome the effects of LRT obstruction at rest is that horses with acute LRT obstruction could still exercise as well without treatment as with treatment, due to their own ability to dilate airways [19].

This common cause of DDSP in sport and pleasure horses is unlikely to be the etiology of DDSP in racehorses because race performance could not be performed with such severe LRT obstruction. The most typical cause of DDSP—the ventrally and caudally positioned larynx—in gallop horses is not eliminated in sport horses. However, even if there is a configuration problem such as this in a sport horse, it is unlikely to cause DDSP in the absence of high strap muscle activity. We propose that poll flexion would rather impede the manifestation of DDSP of extrinsic cause in sport horses, whereas the extended neck and the high speed predispose to it in gallop horses.

Concerning the correlation of resting and exercising endoscopic examinations, it is reasonable to sort the cases by the suspected causes. We suggest that this correlation is the highest in DDSP cases caused by LRT inflammation and/or obstruction.

Based on our results, in complex cases where grade C ACC, VCC, and DDSP occur simultaneously, alternatively a ventriculocordectomy could sufficiently decrease the negative pressure and therefore might prevent the soft palate from having a tendency to become displaced dorsally.

A characteristic abnormal respiratory noise of racehorses during DDSP is the gurgling sound [20], but the functional disease can also stay silent or occasionally generate coughing [10]. In our case series, each horse was coughing during DDSP, which could be explained by hypersensitivity of the airways due to URT and/or LRT inflammation. The absence of the gurgling sound in sport and pleasure horses might be explained by the fact that their expiratory airflow does not reach a speed at which the free border of the soft palate resonate in the same way like in racehorses, as reported in the study by Van Erck–Westergren [10].

LHP is a distal axonopathy of the recurrent laryngeal nerve with clinical manifestation predominantly (95%) on the left side. Performing exercising endoscopy plays an important role in understanding LHP cases. First of all, it is possible to observe whether the condition worsens during exercise or alternatively if it gets compensated during high-intensity work. Moreover, even in those cases where we observed complete paralysis (grade 4), which cannot change during work, exercising endoscopy still plays a role by making it possible to gather information about VCC, which is commonly seen in horses with LHP and can be exclusively observed during exercise [1]. Severe manifestations are common in sport horses, which can be explained by the progressive nature of the disease, which gets increasingly severe with age.

In those of our cases where a significant ACC occurs during exercise and leads to abnormal respiratory noise, it is rare that the resting examination remains subclinical; however, LHP cannot be completely ruled out by resting endoscopic examination as it is documented in our case series and other cases described in the literature [21–23].

It is debated whether poll flexion impacts LHP. Rider intervention with poll flexion is thought to have an effect on laryngeal function and stability in sport horses [10]. According to another study [24], there is no correlation between laryngeal function and neck flexion. In one of our cases, we found that head and neck flexion significantly increased the collapse of the arytenoids. This case was a typical poll flexion–induced bilateral ACC with the simultaneous occurrence of VCC. The pathogenesis of this disorder is not fully understood. It is suspected that the underlying cause is not the distal axonopathy of the recurrent nerve but most likely a conformational change associated with poll flexion, when a more rostral position of the larynx occurs [25,26].

Exercise-induced pulmonary hemorrhage is a common disorder of racehorses [27], but it is not an exclusive characteristic of Thoroughbreds and standardbreds. Two of our sport horses had EIPH. In both cases, besides the hemosiderophage-positive BAL fluid, there were outstanding URT obstructions (LHP and VCC) observed. Regarding the relation of LHP and EIPH, it has been proposed that a horse may need less strenuous exercise for the development of EIPH with more severe URT obstruction [28]. Another study suggests that inspiratory obstruction in exercising horses causes an increase in transmural pulmonary capillary pressure gradient. This may contribute to loss of capillary integrity and lead to the rupture of the pulmonary capillaries [29].

The recently published consensus statement on EIPH does not examine the relationship or the possible relationship between the URT and EIPH. We are highlighting that the evidence on this association is rather weak because of the few published data regarding it [30].

According to the theory that EIPH is related to URT obstruction, the diagnosis and treatment of URT obstruction are essential in these cases. From the two cases where EIPH and LHP appeared simultaneously, one also had IAD. In cases such as this, our conclusion is that reducing inflammation of the LRT should be a priority during initial treatment because both URT obstruction and EIPH can be associated with IAD.

Even though LHP is a typical feature of large horses, in our caseload, ACC appeared in two ponies with severe poor performance. Initially, we started to treat the simultaneous LRT obstruction, which effectively improved the performance of the horses and decreased the PI, which is commonly seen in ponies. There is a possibility that simultaneously occurring PI and IAD might explain the LHP, which was more visible in these cases than what is usual in ponies. We are still investigating whether a sport or hobby horse's performance would be affected by an intermittent grade B ACC and VCC. Based on our search of the literature, this question has not yet been fully addressed in previous studies.

In all cases of dynamic PHC, there was evidence of decreased pharyngeal diameter visible on the OE image, although in less severe cases, this feature only appeared when the horse became fatigued. The abnormal respiratory sounds increased in parallel with poll flexion of the neck or fatigue of the horse. Rider modification with a less intensive poll flexion could be recommended in such cases. The surgical option is resection of the salpingopharyngeal fold [31].

By measuring plasma lactate levels—in a population where anaerobic state due to the intensity of the work is unlikely to appear—our goal was to investigate if a severe URT obstruction may cause increased lactate levels secondary to a suspected arterial hypoxemia during exercise, even if the workload is not excessive. In contrast to racehorses and Grand Prix sport horses [32], measurement of the plasma lactate levels was not informative in our cases, and the anaerobe–aerobe margin (4 mmol/L) was never exceeded. The significant decrease of exercising plasma lactate levels compared with resting levels could be explained by increased clearance during exercise.

Even in cases where severe or multiple obstructions were observed, owners might not perceive poor performance, which could be explained by the difficulties of objective performance measurement in sport horses by both the owner and the veterinarian.

5. Conclusions

Even a very small functional change in the URT can lead to poor performance in racehorses, which usually manifests at strenuous exercise. However, in sport horses, even a severe URT obstruction might not be obvious to the owner. Hence, it is essential to find an objective way to measure poor performance in sport horses.

Although the management of DDSP must be tailored to the cause, the treatment of LHP is independent of the underlying cause.

The weakness of the report is that because it is a clinical study, only those examinations could have been performed which were necessary for diagnostics.

We suggest that the use and/or discipline of the horse should be taken into account, when evaluating configuration problems of the URT; for example, in racehorses, a caudally and ventrally positioned larynx is disadvantageous, whereas in sport horses, the rostral position of the larynx can lead to URT obstruction during poll flexion.

It is important to treat the URT and LRT as a single unit because LRT disorders can often cause URT functional disease (e.g., RAO–DDSP), although URT obstructions could be a factor in LRT problems (LHP–EIPH).

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