Diagnosis of upper respiratory tract disorders in horses using a cheap, smartphone-connected, flexible and steerable borescope

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Summary

Background: Endoscopy is essential for the diagnosis of upper respiratory tract (URT) disorders in horses but equipment is expensive. An industrial borescope might be used to visualise the URT when an endoscope is not available.

Objectives: To investigate the applicability of a cheap smartphone-connected flexible and steerable borescope to perform URT endoscopy in horses.

Study design: Prospective descriptive study.

Methods: In horses with a clinical indication, endoscopy was first performed with a borescope (Mini Endoscope Camera 360° Steering 720P Borescope 8mm USB Model LMS-DW154; 210 Euro) and subsequently with a veterinary endoscope (TXHD136-9D, Dr. Fritz, Germany), which was used as gold standard. Typical URT structures of interest (depending on clinical signs) were digitally recorded. Recordings of both examinations were reviewed by a blinded observer.

Results: One hundred horses underwent both endoscopic examinations via the right (n=100) and left (n=24) nasal passage. In 81/83 attempts, the ethmoid and sinus ostia were visualised on the right side and in 22/24 attempts on the left side. Pharyngeal and laryngeal structures could always be visualised except in 6 horses where the tip of the epiglottis could not be seen

due to technical failure of the steering mechanism. In 66/72 attempts, the trachea could be visualised proximally, of which in 59 as far as the carina. Borescope and endoscope grading scores for pharyngeal lymphoid hyperplasia, recurrent laryngeal neuropathy and tracheal mucus were identical in 88/100, 93/100 and 48/59 horses, respectively. The remainder differed only one or two subgrades. The borescope was replaced halfway the study as the steering mechanism started to fail after 45 to 50 examinations.

Main limitations: Lack of reliability and the absence of a working channel of this particular borescope model.

Conclusions: A flexible, steerable borescope, connected to a smartphone, allows visualising specific parts of the URT in horses.

Keywords: horse; endoscopy; alternative; upper airway; recurrent laryngeal neuropathy

Clinical relevance:

- A borescope is very cheap and allows visualising parts of the upper airways in horses.
- Upper respiratory tract disorders can be diagnosed with a borescope.
- A borescope might be applied for URT examination when an endoscope is not available.

Introduction

Respiratory tract disorders in horses are common and are important causes of poor performance (Morris and Seeherman 1991; Martin *et al*. 2000; Van Erck 2011). Endoscopic evaluation of the equine upper respiratory tract (URT) is the most commonly used diagnostic technique as the nasal passage, pharynx, larynx, guttural pouches, sinus ostia, ethmoid, pharyngeal recess and trachea can be visualised (Davidson and Martin 2003; Sheta and Ashour 2017). However, this specialized equipment is expensive and therefore not always available. Furthermore, the

equipment is fragile, sometimes of substantial size and systems are not always practical to use in the field. A borescope is an endoscope without a medical quality label, mainly used in the industrial sector, for example, for visual inspection of engines. Borescopes can be rigid or flexible and even steerable, and most systems can be connected to a computer or smartphone. Depending on the type of borescope, the price is 10 to 100 times cheaper than a medical endoscope. As such, a borescope might be used in horses when an endoscope is not available. The aim of this study was to determine whether parts of the equine URT can be visualised and whether URT disorders can be diagnosed using a borescope.

Materials and Methods

The study was approved by the Animal Ethics Committee of the Faculty of Veterinary Medicine, Ghent University and owner informed consent was obtained. The study included horses presented at the Department of Large Animal Internal Medicine of Ghent University, with clinical signs of a respiratory disorder, such as a respiratory noise at rest and/or during exercise, non-orthopaedic poor performance, nasal discharge or coughing. In addition, endoscopy was performed in mares from a stud farm with a history of laryngeal collapse in several horses. Gender, age, breed and height at the withers were recorded. The applied borescope[1] (Figure 1) was a simple waterproof model, steerable in two directions using a wheel on the handle of the device, which allowed a 180 degrees flexion in each direction. The 8 mm diameter distal head was flexible, contained 6 LED lights and had a smooth rubber surface over 5 cm. The remainder of the borescope, which had a total usable length of 2 meter, had a ribbed surface. In order to avoid mucosal irritation, the working length of the borescope was covered with a 120 cm long, 2 mm thick rubber tube[2] which had an inner diameter of 8 mm. The examination was carried out as a standard endoscopy procedure. Because of the absence of a working channel, no attempts were made to enter the guttural pouches and performing a tracheal aspirate sampling was not possible. Structures of interest were visualised depending on the

clinical signs. Therefore, not all structures or sides (right and left) were attempted to be looked at in all horses. The borescope was cleaned between each horse using a 0.05% chlorhexidine solution. The examination was recorded on a smartphone[3] through a specialized, free of charge, application[4]. Subsequently, the same examination was repeated using an equine videoendoscope[5]. The examination was recorded on a computer[5] using an adapted software[6]. Both borescope and endoscope recordings were reviewed in random order on a computer by an observer blinded for all patient details. For each examination, each visualised URT structure was noted. In addition, pharyngeal lymphoid hyperplasia (PLH), RLN and tracheal mucus score were graded (Raker and Boles 1978; Dixon *et al.* 2003; Gerber *et al.* 2004) and a diagnosis was made. Borescope image quality was scored as follows: 0= poor quality, a diagnose could not be made or the URT structures could not be visualised due to poor image quality; 1= moderate quality with some mucus or mist but diagnosis and visualisation of the URT structures was possible; 2= good quality, a diagnosis could be made and the URT structures were clearly visible.

Results

One hundred horses were examined: 93 mares and 7 geldings, including Trotter horses (n=73), Warmbloods (n=14), Connemara pony (n=1), Arabian horse (n=1) and unknown breeds (n=11). Mean age was 8.1 years (range 3-20) and mean (± standard deviation) height at the withers was 162 ± 6 cm. The right (n=100) and left (n=24) nasal passages were visualised with the borescope. During the insertion into the nasal passage, the flexible distal head of the borescope occasionally flipped backward until the pharynx was reached. The visualisation of the ethmoid and sinus ostia could be observed in 81 of the 83 attempts (97.6%) on the right side and 22 of 24 (92%) on the left. Pharyngeal recess (n=95) and both (n=96) or the right (n=4) guttural pouch openings could always be observed when attempted (100%). The pharynx and larynx were visualised in all horses except in 6, where the tip of the epiglottis could not be seen. With the

borescope, intermittent dorsal displacement of the soft palate (IDDSP) could be seen in 22 horses. Evaluation of the entire trachea (as far as the carina) (Figure 2) was successful in 59/72 attempts (82%), while in 7 horses only the proximal trachea was visualised (9.7%). In 6 horses (8.3%) the trachea could not be entered. In all horses (n=100) PLH and RLN were graded. Grading of the PLH and RLN were identical on the borescope and endoscope images in 88/100 and 93/100 horses, respectively. Tracheal mucus score was assigned in the 59 horses where the trachea was visualised as far as the carina. It was not possible to give a score in 5 horses due to mucus accumulation on the borescope lens. The mucus scores were the same in 47/54 (87%) horses. In one horse, food particles were present in the trachea and visualised with both examination systems. From the borescope images, diagnosis of URT disorder at rest was made in 63 horses, including PLH (Figure 3), RLN (Figure 4), IDDSP (Figure 5), petechia on the pharynx roof, mucus in the nasopharynx or trachea (Figure 6) and alimentary content in the trachea. Viewing in all directions with the bidirectionally steerable borescope, required a combination of steering and rotation of the device which resulted in a tilted or even upside-down image on screen. In 10 horses, signs of superficial mucosal irritation of the nasal passage or arytenoid were observed during the second examination. Image quality of the borescope was always of sufficient quality to make a diagnosis (score 1 or 2), except in two horses because of mucus on the lens. Mean score of the blinded observer was 1.13. After examining approximately 50 horses the steering mechanism of the borescope started to fail, resulting in a reduced steerability with only flexion of 20 degrees in both directions possible. The same happened with the second borescope at the end of the study.

Discussion

This study investigated the applicability of a simple, 210 Euro borescope to visualise the equine upper airways and the feasibility to diagnose URT disorders at rest. In our study, applicability and diagnostic ability were good. Image quality was good and allowed to make a diagnosis.

Reviewing the recordings on a computer screen instead of a smartphone might have affected the scoring results because of a different resolution and the inability to rotate the screen. In case of a difference in PLH grade, the borescope grade was higher because the lens was often closer located to the pharyngeal wall compared to the endoscope as a result of the preformed curvature, giving the follicles a larger appearance on screen. In 93% of the cases, RLN grades from borescope and endoscope images were identical, and the remainder only differed by one or two subgrades. The slight difference in the 7 remaining horses may be related to the variability in grading endoscopic images (Perkins *et al*. 2009). Tracheal mucus score differences may be attributed to coughing between both procedures, a suboptimal, usually lateral, position of the borescope in the tracheal lumen and the fact that the borescope image was often tilted on screen making interpretation more difficult. The borescope used in this study had a short life-span, probably related to the fact that in some horses, the head of the borescope flipped back during insertion in the nasal passage. Using another borescope model, for example one with steering possible in 4 directions, a more rigid head, less rigid body and of better quality and durability might have overcome this issue. However, even with the limited number of examinations, the borescope remained a cheap option to examine specific URT structures in horses. Disadvantages of the borescope were its poor durability, the rigid body that needed a pre-curvature, the ribbed part that needed to be covered by a rubber tube and the absence of a flushing system for the lens. In addition, no working channel was present which prevented the passage of a stylet to enter the guttural pouches. Our study had several limitations. Only one type of borescope was evaluated. The order of borescope and endoscope examination was not randomised. However, performing the study with the borescope first and afterwards with the veterinary endoscope allowed assessing the applicability and ability to make a diagnosis in a real clinical setting and this order also allowed visualisation of any mucosal trauma. Finally, examinations were only performed once in each horse. In a clinical setting the examination

would be repeated after adjusting the curvature, but this was not performed in our study. The single examination also did not allow assessing repeatability or reproducibility.

Conclusion

In conclusion, this simple, very cheap smartphone-connected flexible and steerable borescope allowed visualising parts of the URT in horses. Images could be recorded on a smartphone and image quality was sufficient to diagnose URT disorders in horses.

Declarations

No conflicts of interest have been declared.

Acknowledgements

None.

Manufacturers' addresses

[1]Mini Endoscope Camera 360 degree Steering 720P Borescope 8mm USB Model LMS-DW154.

[2]Holleen BVBA, Meeuwen-Gruitrode, Belgium.

[3]LG Android V30,Yeoui-daero, Yeongdeungpo-gu, Seoul, Korea

[4]Inskam, Xinmu Village, Pinghu, Longgang District, Shenzhen, China.

[5]Dr. Fritz GmbH, Tuttlingen, Germany.

[6]ArcSoft ShowBiz, Softonic International, S.A., Barcelona, Spain.

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Figure legends

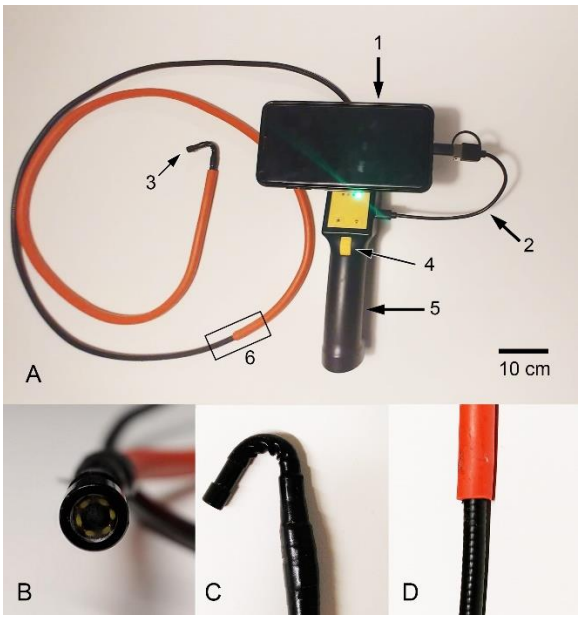

Figure 1: A. A smartphone (1) is connected to the borescope by a usb cable (2). The head of the borescope (3) is bi-directionally steerable over 180 degrees using a steering wheel (4) on the handle (5) of the borescope. B. Front view of the head with 6 LED lights. C. Head of the borescope in a curved position. D. A detail of the borescope (6) shows how the ribbed part is covered by the rubber (orange) tube.

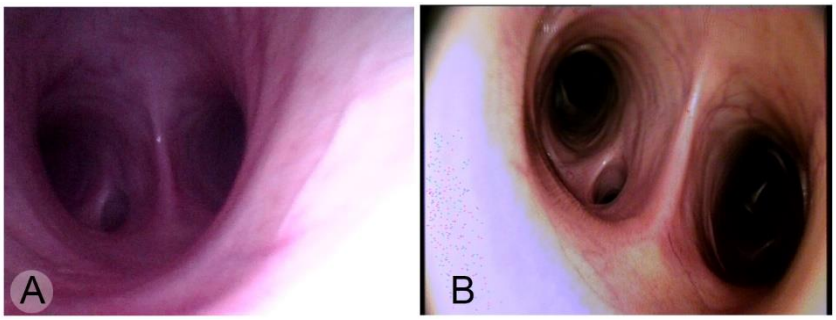

Figure 2: Images of a carina taken with the borescope (A) and the veterinary endoscope (B) in the same horse.

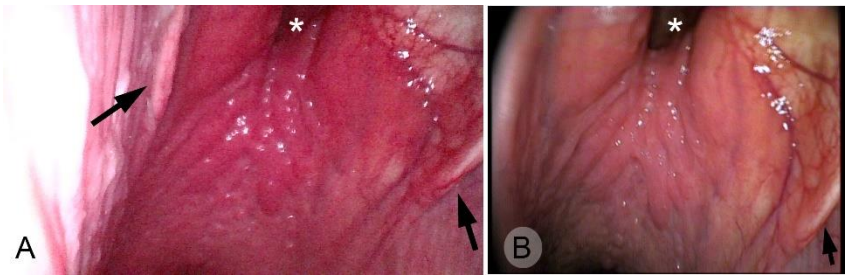

Figure 3: Visualisation of the pharynx in the same horse with pharyngeal lymphoid hyperplasia grade IV using the borescope (A) and endoscope (B). The guttural pouch openings (black arrows) and pharyngeal recess (white asterisk) can be identified.

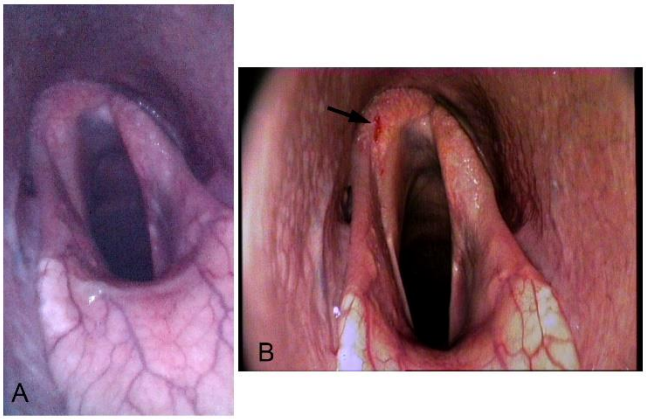

Figure 4: In this horse, RLN grade IV can be identified on the borescope (A) and endoscope (B) images. The black arrow on the endoscopic image indicates superficial mucosal trauma as a result of the borescope passage.

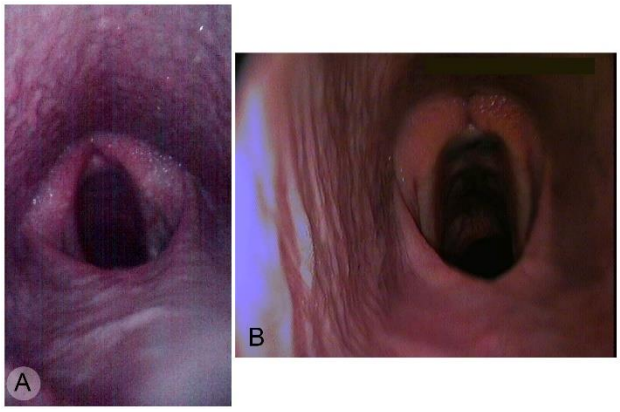

Figure 5: Intermittent dorsal displacement of the soft palate visualised with the borescope (A) and the veterinary endoscope (B) in two horses.

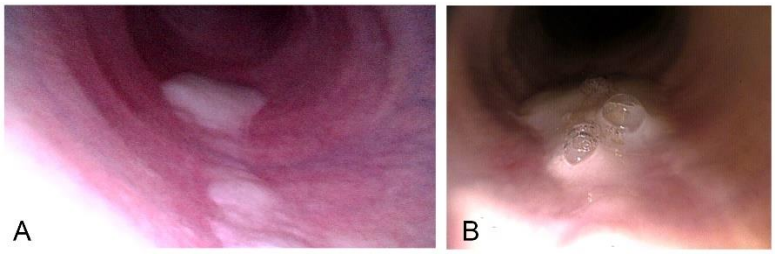

Figure 6: In this horse, tracheal mucus is identified with the borescope (A) and endoscope (B).