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# Evaluation of the Cranial Cruciate Ligament Repair System® in Surgery for Laryngeal Hemiplegia in Heavy Draft Horses

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*The purpose of this study was to evaluate the effect of the canine cranial cruciate ligament repair system on laryngeal hemiplegia in heavy draft horses. Twenty-four heavy draft horses diagnosed with grade 4 laryngeal hemiplegia were allocated to either the prosthetic laryngoplasty (PL) group (n=14) or a canine cranial cruciate ligament repair system (CCCLRS) group (n=10). Right to left angle quotients (RLQs) of abductions of the arytenoid cartilages were endoscopically evaluated before and after surgery. Post-operative RLQs in the CCCLRS group were significantly lower than those of the PL group (P<0.01). The canine cranial cruciate ligament repair system was revealed to be a good surgical procedure for laryngeal hemiplegia in heavy draft horses.*

**Key words:** *canine cranial cruciate ligament repair system, equine, laryngoplasty*

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Heavy draft horses frequently develop upper respiratory diseases [1]. Specifically, cases in which inspiratory noise is noted during training or running and which develop exercise intolerance later are endoscopically diagnosed as laryngeal hemiplegia and laryngoplasty is performed [5, 7]. However, conventional prosthetic laryngoplasty is known not to allow sufficient abduction of arytenoid cartilages in heavy draft horses.

In recent years, favorable results have been reported for the canine cranial cruciate ligament repair system (CCCLRS), which uses an oval crimp clamp, in cranial cruciate ligament repair in dogs [8]. This study was conducted to evaluate the effect of CCCLRS on laryngeal hemiplegia in heavy draft horses. Conventional prosthetic laryngoplasty (PL) and CCCLRS were performed and angles of abductions of arytenoid cartilages were compared between before and after the surgery.

Horses (N=24) with abnormal respiratory noise and/or exercise intolerance were examined, and a diagnosis of grade 4 left laryngeal hemiplegia during inspiration was confirmed at rest using videoendoscopy. The degree of left laryngeal hemiplegia was graded according to the criteria described by Hackett *et al.* [2]: Grade 1- synchronous full abduction and adduction of the left and right arytenoid cartilages; Grade 2- asynchronous movement (hesitation, flutter, adductor weakness, etc.) of the left arytenoid cartilage during any phase of respiration. Full abduction of the left arytenoid cartilage (as compared to the right) inducible by nasal occlusion or swallowing; Grade 3- asynchronous movement (hesitation, flutter, adductor weakness, etc.) of the left arytenoid cartilage during any phase of respiration, and full abduction of the left arytenoid cartilage cannot be induced and maintained by nasal occlusion or swallowing; Grade 4- marked asymmetry of the larynx at rest and no substantial movement of the left arytenoid cartilage during any phase of respiration; and Grade 5- laryngeal asynchrony or asymmetry not included in any of the previous grades.

The subjects were randomly allocated to the PL and CCCLRS groups. The PL group consisted of 14 horses that underwent the procedure between January 2004 and December 2006 (mean age 3.8 ± 3.6 years, mean body weight 1,017.1 ± 67.3 kg, 13 males and 1 female).

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The CCCLRS group consisted of 10 horses that underwent the procedure between January and July 2007 (mean age 4.4 ± 1.8 years, mean body weight 1,004.6 ± 33.7 kg, 14 males).

Lateral exposure of the larynxes and suture placement were performed as described by Marks *et al.* [6]. Horses were administered medetomidine (4 $\mu$g/kg) and diazepam (0.03 mg/kg) intravenously (IV). Anesthesia was induced with ketamine (2.2 mg/kg) and maintained with isoflurane in oxygen combined with an IV triple drip solution (ketamine [1 g], xylazine [500 mg], guaiafenesin [500 m*l* 5% solution]) at 1–2 m*l*/kg/hr. Horses were positioned in right lateral recumbency with their heads fully extended. Three to four small fluid-filled bags were positioned under the laryngeal area to raise the larynxes and gain better access to the deeper structures. After aseptic skin preparation, the larynxes were accessed by incision between the linguofacial vein and the omohyoid muscle. The prosthesis was fixed caudally through the cricoids cartilage as close to the midline as possible.

In the PL group, the cricopharyngeal muscle was then incised (≥2 cm) from the larynx to permit passage of a USP 5 polyester suture coated with polybutilate (Ethibond, Ethicon, Inc., Somerville, NJ, USA). The suture was passed through the muscular process craniolaterally. Optimal implant placement was intended to mimic the orientation of the dorsal cricoarytenoid muscle. The degree of arytenoid abduction was assessed intraoperatively with a videoendoscope, which was secured in position until the desired degree of abduction was obtained. Once the suture was drawn through the muscular process, it was pulled tight to ensure that there was no hidden slack. The trailing end of the suture was then drawn under the cricopharyngeal muscle.

In the CCCLRS group, the cricopharyngeal muscle was incised (≥2 cm) from the larynx to permit passage of the swaged needle (Securos Tie back system, 80lb. monofilament suture, Securos, Inc., Veterinary Orthopedics, Charton, MA, USA) [8]. The needle was passed through the muscular process craniolaterally. Optimal implant placement was intended to mimic the orientation of the dorsal cricoarytenoid muscle. After implant insertion, the needle was removed by cutting the suture and each suture was threaded in opposite directions through an oval crimp clamp. Modest tension was applied with the extended index fingers of both hands to flatten the prosthesis against the larynx. There was sufficient resistance in the system to maintain the tension on the suture. A round crimp clamp was applied to each suture end, 5 mm on either side of the oval crimp clamp. Each round clamp was fastened to the sutures using 2 applications each of the crimping device. The tensioning device was then placed in position on both suture ends and its branches were engaged on the round crimp clamps. Tension was then applied to the suture incrementally by a ratchet mechanism. With the horses extubated, the effect of increasing suture tension on arytenoids abduction was observed by transnasal endoscopy. Using the ratchet mechanism, arytenoid cartilage positions were altered to the desired degrees of abduction [5]. The oval clamp was then crimped 3 times to the prosthesis and the suture ends were cut off. The surgical sites were closed in layers (2–0 synthetic absorbable suture, Coated Vicryl, Ethicon, Inc., Somerville, NJ , USA).

Horses were intramuscularly administered with 22,000 IU/kg body weight of potassium penicillin (Penicillin G, Meiji Inc., Japan) immediately before surgery and every 24 hr after surgery for 48 hr. The skin incisions were cleaned twice daily until healed using moist gauze sponges. The horses were confined to stalls for 30 days except when hand walked for daily

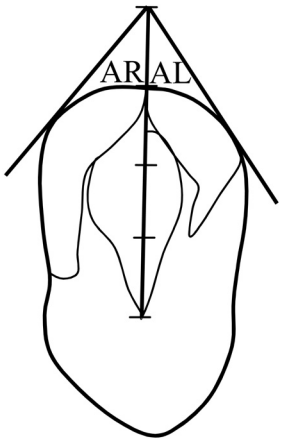


**Fig. 1.** An illustration of the larynx and RLQ calculation. Diagnosis of left laryngeal hemiplegia during inspiration was confirmed at rest using videoendoscopy. A vertical line connecting the proximal-most and the distal-most points of the rime glottidis is extended for a distance of one third of the line length in a dorsal direction(⊢⊣). From the end of this line, tangential lines to both of the arytenoids cartilages are drawn. The angles between the right (AR) and left (AL) tangential lines and the vertical line are measured, and RLQ is then calculated by dividing AR by AL.


**Fig. 2.** Photographs of the larynxes in the CCCLRS group during inspiration were taken before and after the surgery. a: the day before the surgery, b: the 30 days after the surgery. Post-operatively in the CCCLRS group, abductions of the left arytenoid cartilages improved as well as those of the right.

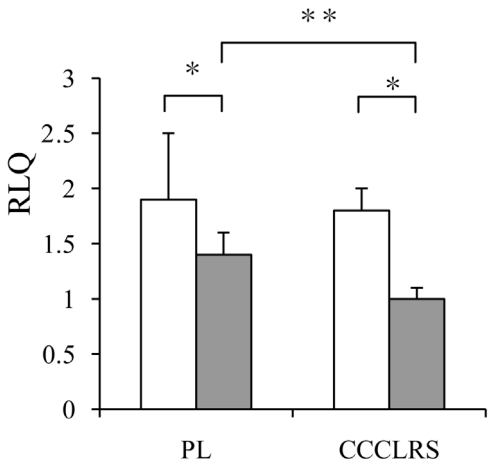


**Fig. 3.** Comparison of RLQ (Right to Left angle quotients) of the PL and CCCLRS groups before and after the surgery. □: before the surgery, ■: after the surgery. Values are mean + SD. **: P<0.01, *: P<0.05.

exercise.

The horses were examined videoendoscopically on the day before and 30 days after the surgery. Degrees of arytenoid abductions were recorded on digital video post-operatively. Photographs of the larynxes during inspiration were taken before and after the surgery using computer software (Windows Media Player, Microsoft Inc, USA). Using the photographs, right to left angle quotients (RLQs) were calculated as described by Herholz and Straub [3]. This method involves drawing a line connecting the dorsal- and ventral-most points of the rima glottidis and then, extending the line dorsally to a distance of one third of the dorsoventral height of the rima glottidis. Tangential lines to both of the arytenoid cartilages are drawn, and the angles between the dorsoventral line and the tangents are measured (Fig. 1). The resulting quotient obtained by dividing the right angle with the left angle indicates the degree of the left arytenoid abduction.

All results from the tests are expressed as mean ± SD. To evaluate the significance of RLQs between the PL and CCCLRS groups, the Mann-Whitney U test and Welch's *t*-test were used. The Wilcoxon test was used for RLQs measured before and after the surgery in the PL and CCCLRS groups. Statistical significance was determined to be a p value of less than 0.05.

CCCLRS involved easier suturing compared to conventional PL and allowed favorable abduction of the arytenoid cartilages (Fig. 2). Abnormalities such as post-operative infection were not observed in the PL and CCCLRS groups. RLQs of the PL group significantly decreased from 1.9 ± 0.6 (before the surgery) to 1.4 ± 0.2 (after) (P<0.05), and abductions improved (Fig. 3). Similarly, RLQs of the CCCLRS group significantly decreased from 1.8 ± 0.2 (before) to 1.0 ± 0.1 (after) (P<0.01) and improvement of abductions was observed. The post-operative RLQs of the CCCLRS group were significantly lower than those in the PL group (P<0.01) and abductions of the left arytenoid cartilages improved as those as that of the right. Dyspnoea during exercise and exercise intolerance disappeared in horses in the CCCLRS group. On the other hand, dyspnoea and exercise intolerance did not disappear completely, though it did decrease in horses of the PL group.

The monofilament of CCCLRS is designed to tolerate up to 80 lbs. of tension [8]. With the aid of the ratchets, optimal tension was preserved in the larynxes of heavy horses when sutured. Further, the oval crimp clamp and the crimping device helped to keep the prosthesis firmly tied, and laryngoplasty was readily performed. The ratchet mechanism of the tensioning device facilitated abduction of the arytenoid cartilage and suture fixation was achieved by crimping the clamp without any loss of tension.

RLQs show the ratio of the angle of abduction of the right arytenoid cartilage to that of the left arytenoid cartilage, and values of >1.0 indicate downward displacements of the left arytenoid cartilages [8]. When laryngoplasty results in improvement of abduction on the left side, the RLQ becomes closer to 1.0 [3]. In our study, post-operative RLQ of the PL

group was 1.4, suggesting that conventional PL does not completely resolve abduction have of the left arytenoid cartilage. We consider this is because heavy horses have well-developed muscles around the larynx and firm joints that surround arytenoid cartilages. In the CCCLRS group, post-operative RLQ was 1.0, and improvements of abduction as well as relief of dyspnoea and exercise intolerance were demonstrated.

This study shows that CCCLRS is a good surgical procedure for laryngeal hemiplegia in heavy draft horses.

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