Freely-Behaving Videofluoroscopic Characterization of Dysphagia in Canine Degenerative Myelopathy

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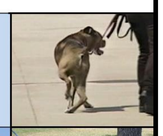
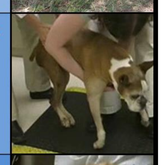
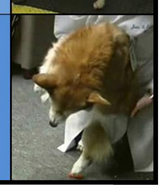
Introduction

Canine Degenerative Myelopathy (DM) has recently been proposed as a naturally occurring disease model for human amyotrophic lateral sclerosis (ALS). In both DM and familial ALS, the disease phenotype is attributed to a mutation in the *superoxide dismutase 1* (*SOD1*) gene. Clinical signs observed in DM dogs are similar to those seen in ALS patients. Dysphagia (swallowing impairment) develops in almost all patients with ALS at some point in the disease process. Likewise, clinical signs of dysphagia have been reported in DM as the disease progresses to end-stage [Table 1]. Previous work in this laboratory developed a protocol for a freely-behaving videofluoroscopic swallow study (VFSS) that allows dogs to consume foods and liquids containing either barium or Omnipaque™ (iohexol) contrast agents while standing unrestrained in a custom-designed polycarbonate, radiolucent kennel. The kennel setting eliminates the need for physical restraints and force-feeding techniques that may result in unnatural feeding activity, which is a common complaint reported in the canine VFSS literature. Using our freely-behaving VFSS protocol, **we hypothesize that several biomarkers for dysphagia will be identified in DM-affected dogs, compared to unaffected control dogs.** Correlations between dysphagia phenotype and histopathology in DM can then be explored and compared with human ALS. This research is necessary to validate canine DM as a disease model of ALS.

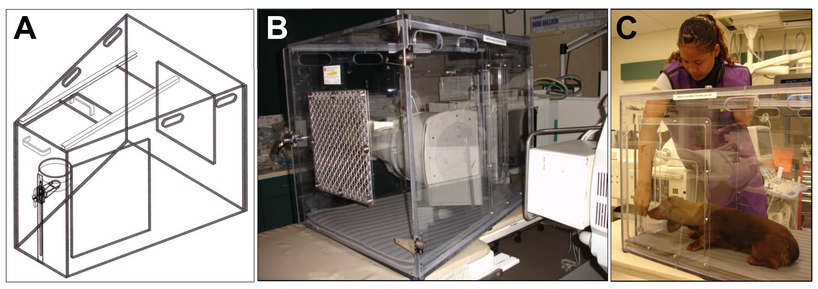
Table 1: Stage of neurological signs in DM dogs

Stage	Neurologic Signs	
1 Early	**UMN Paraparesis** • Progressive general proprioceptive ataxia • Asymmetric spastic paraparesis • Intact spinal reflexes	
2 Early	**Nonambulatory Paraparesis to Paraplegia** • Mild to moderate loss of muscle mass • Reduced to absent spinal reflexes in pelvic limbs • +/- urinary and fecal incontinence	
3 Late	**LMN Paraplegia to Thoracic Limb Paresis** • Signs of thoracic limb paresis • Flaccid paraplegia • Severe loss of muscle mass in pelvic limbs • Urinary and fecal incontinence	
4 Late	**LMN Tetraplegia and Brain Stem Signs** • Flaccid tetraplegia • Difficulty with swallowing and tongue movements • Reduced to absent cutaneous trunci reflex • Generalized and severe loss of muscle mass • Urinary and fecal incontinence	

Goals and Objectives

- Evaluate key swallow parameters in healthy dogs of similar anatomical size using the freely-behaving VFSS protocol.
- Establish normative values for comparison with DM-affected dogs and other diseases that cause dysphagia.
- Create a protocol for freely-behaving VFSS to use in the clinical setting as a diagnostic tool.

Observation Kennel



A transparent, trapezoid-shaped observation kennel was made from Lexan®, a radiopaque polycarbonate material. An adjustable radiopaque bowl attaches to the narrow end to limit mobility of the dog and eliminating the necessity of a person being exposed to radiation while holding the dog in place. (A) CAD drawing of the observation kennel. (B) Prototype observation kennel positioned for videofluoroscopy. (C) Dachshund in the observation kennel.

Materials and Methods

VFSS Protocol

1	Overnight food restriction
2	Prepare test items with oral contrast agent immediately prior to use
3	Position kennel in fluoroscope
4	Place first test item in kennel ring and position it at desired height
5	Allow dog to freely enter kennel to consume test item from bowl
6	Record 4 consecutive swallows with head and neck in field of view
7	Follow 4th swallow to stomach
8	Repeat steps 6 & 7
9	Replace bowl with next test item
10	Repeat steps 6 - 9 until all items have been tested
11	Allow dog to freely exit kennel
12	Clean kennel

Swallow Parameters Measured

We measured 2 swallow parameters using thin liquid and kibble swallows in 8 healthy dogs for comparison with published values for lateral and sternal recumbency (Bonita et al., 2009).

- **Time to maximal pharyngeal constriction**: The time from start of swallow until pharyngeal muscles are maximally constricted.
- **Time to upper esophageal sphincter (UES) closure**: The time from start of swallow until complete UES closure after passage of bolus into esophagus.

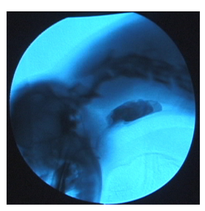
Contrast Agents (Indications and Contraindications)

Indications / Contraindications	Barium	Omnipaque™
Adult patient	+	+
Young/neonate patient	-	+
Allergies	-	+
Aspiration risk[1]	-	+
Cardiac disease[2]	-	-
Constipation/Obstipation	-	+
Dehydration	-	-
Diarrhea	+	-
Discriminating eater	-	+
Esophageal airway fistula	-	+
Hepatic disease[2]	-	-
Leakage risk[2]	-	+
Nausea	+	-
Lactation	+	-
Pneumonia	-	+
Pregnancy	+	-
Renal disease[2]	-	-
Severe dysphagia	-	+
Thyrotoxicosis	+	-
Vomiting	+	-

[1]Use Omnipaque™ to screen aspiration; if no aspiration, barium also can be used .
[2]Use caution with all contrast agents for patients with cardiac, renal, or hepatic diseases.

Results

Maximal Pharyngeal Constriction



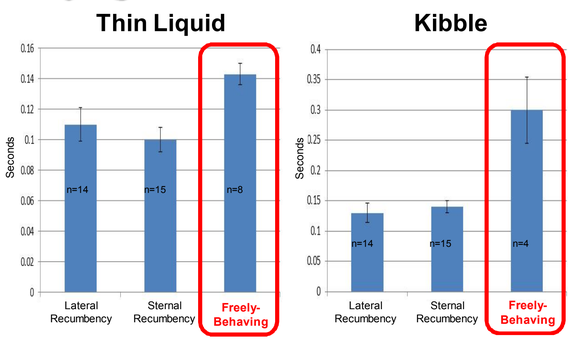
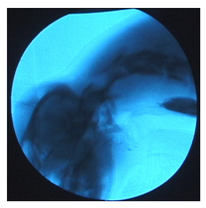


Figure 1. Time to maximal pharyngeal constriction (MPC). The fluoroscopic image represents a frame illustrating MPC. The graphs depict study of thin liquid and kibble swallows in 8 healthy dogs and compared to published values for lateral and sternal recumbency (Bonita et al., 2009). The error bars represent the standard deviation. The mean time to MPC for both freely-behaving thin liquid and kibble trials is longer than the mean times for lateral and sternal recumbent positions.

Upper Esophageal Sphincter Closure



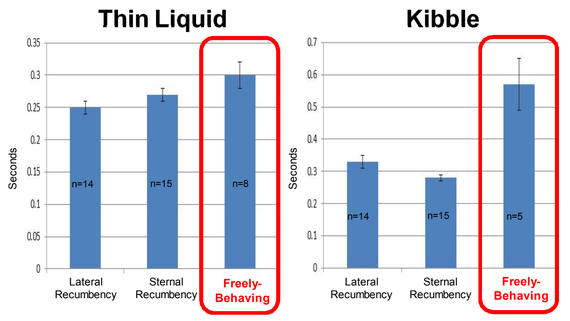


Figure 2. Time to Upper Esophageal Sphincter (UES) Closure. The fluoroscopic image represents a frame illustrating UES closure. The graphs depict study of thin liquid and kibble swallows in 8 healthy dogs tested in the observation kennel and compared to published values for lateral and sternal recumbency (Bonita et al., 2009). The error bars represent the standard deviation. The mean time to UES closure for both freely-behaving thin liquid and kibble trials is longer than the mean times for lateral and sternal recumbent positions.

Summary and Conclusion

- A summary of indications and contra-indications for use of barium and Omnipaque™ contrast agents was created as a clinician-friendly tool for this freely-behaving VFSS protocol.
- Current literature recommends use of Omnipaque™ for VFSS as a **safe** alternative and is often preferred over commonly used barium.
- To date, 8 controls and 3 DM-affected dogs have been evaluated using the freely-behaving VFSS protocol. However, video analysis of DM-affected dogs is being deferred until normative data is established.
- Average times for both swallow parameters during freely-behaving trials were longer compared to prior publications. Differences may be attributed to the natural feeding position promoted by this VFSS protocol.

Future Directions

- Establish normative values for several swallow parameters using our freely-behaving protocol. We are currently focusing on small and large breed dogs that are commonly affected by DM (e.g., Pembroke Welsh Corgis and Boxers).
- Continue to recruit DM-affected dogs for evaluation using the freely-behaving VFSS protocol.
- Identify specific videofluoroscopic biomarkers of dysphagia in canine DM.
- Establish the freely-behaving VFSS protocol as an alternative diagnostic tool in veterinary clinical practice.

Study Limitations

- The fluoroscopy machine used for this study is outdated and was incompatible with available digital technology at the time of data collection. Therefore, digital video recording was accomplished using a hand-held video camera focused on the fluoroscopy monitor. However, recent improvements will allow direct digital recordings of the fluoroscopic videos. We anticipate clearer images that will allow us to investigate additional swallow parameters in future testing.
- All dogs do not eat all food consistencies; therefore, the amount of data for each swallow parameter may be variable.

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