U.PORTO
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UNIVERSIDADE DO PORTO

Final Training Report

Master Degree in Veterinary Medicine

DISEASES OF THE GUTTURAL POUCHES

Mário Alfredo Pereira Ferreira dos Santos

Mentor: **Dr. Tiago de Melo Silva Pereira**

Co-Mentor: **Dr. Klaus Hopster**

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ABSTRACT

My externship/professional training period was performed in equine medicine and surgery at the Equine Clinic of the University of Veterinary Medicine Hanover (Germany), which is a well-equipped clinic with a strong caseload and professional team.

During these 16 weeks of training, I have rotated 7 weeks in Equine Surgery, 4 weeks in internal medicine, 2 weeks in orthopedics and 3 weeks in anesthesia/theriogenology. I had the opportunity to perform some medical procedures, general examinations and follow-up of the patients. I have also, participated every week in theoretical and practical courses, in different areas of the equine medicine conducted by the University of Veterinary Medicine Hanover, which allowed me to learn and gain practical skills.

I decided to make my dissertation/thesis about diseases of the guttural pouches, because diseases which affect the guttural pouches are rare, difficult to manage and they can be life-threatening. The successful treatment of these diseases, sometimes is just possible with recent and minimally invasive techniques which are just available in well-equipped clinics, with specialized equipment and experts, as we can find in the equine clinic of the University Veterinary Medicine Hanover.

ACKNOWLEDGEMENTS

I would like to thank my mentor, Professor Tiago Pereira, for his guidance, availability and help during this professional training period and all graduation.

A special thanks to Dr. Jim Schumacher, who is an example to me, a great person.

To my co-mentor for the opportunity to perform this training period at the equine clinic of the University of veterinary medicine Hanover.

To all my friends…

CASELOAD AND PROCEDURES

Equine Clinic of the University of Veterinary Medicine Hanover

Digestive System	**87**
Medical colic	23
Surgical colic	12
Dental and oral pathology	32
Chronic dilation of stomach (overloaded)	1
Dysphagia	2
Imperforate anus	1
Mandibular tumor	1
Abdominal hernia-rupture abdominal muscles	1
Umbilical hernia	1
Inflammation of the parotid gland	1
Gastric ulceration	7
Parotid melanoma	1
Intraabdominal neoplasia (lipoma)	1
Chronic weight loss	1
Gastric and duodenal hypomotility	1
Chronic diarrhea	1

Cardiovascular System	**17**
Thrombophlebitis	1
Mitral regurgitation	4
Tricuspid regurgitation	2
Aortic regurgitation	2
Cardiomegaly	2
Atrial fibrillation	3
Atrial dilation	1
Phlebitis and periphlebitis	2

Musculoskeletal System	**34**
Flexion deformities in foals	1
Mandibular fracture	1
Osteochondrosis/osteochondritis dissecans	9
Tibia fracture	1
Temporal bone fracture	1
Hock abscess	1
Radial nerve paralysis	2
Myopathy	1
Navicular syndrome	1
Metatarsus fracture	1
Equine palmar foot syndrome	1
Kissing spines	2
Laminitis	1
Suspensory desmitis	2
Tendinitis deep flexor tendon	2
Tendinitis superficial flexor tendon	1
Equine onchocerciasis	1
Laceration soft tissue	2
Arthritis	1
Subsolar abscess	2

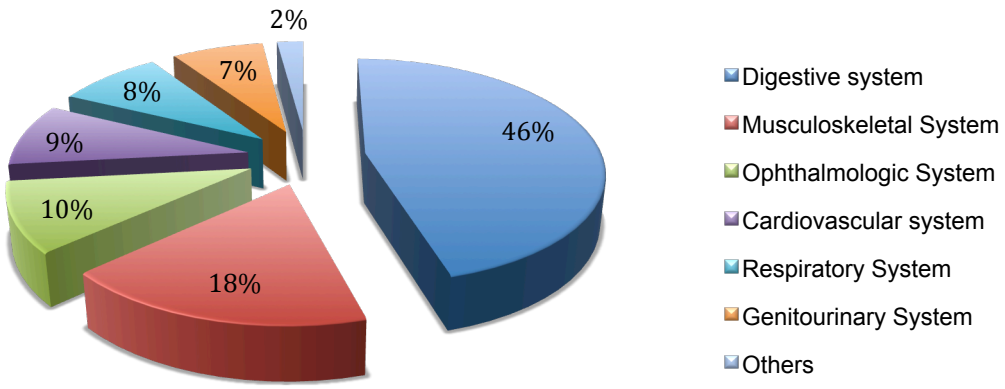
Respiratory System	**16**
Chronic obstructive pulmonary disease	4
Laryngeal hemiplegia	2
Guttural pouch tympany	2
Ethmoid Hematoma	1
Sinusitis	3
Guttural pouch mycosis	1
Pleural mesothelioma	1
Pneumonia	3
Dorsal displacement of the soft palate	1

Ophthalmologic System	**19**
Equine recurrent uveitis	9
Cataracts	2
Orbital fistula	1
Corneal ulceration	3
Neoplasia retrobulbar	1
Conjunctivitis	2
Phthisis bulbi	1

Genitourinary System	**14**
Urolithiasis	1
Urinary incontinence	1
Penile neoplasia	2
Preputial neoplasia	1
Mammary gland carcinoma	1
High-risk pregnancy	3
Dystocia	1
Prepucial edema	1
Azoospermia	1
Testicular atrophy	1
Ovarian hematoma	1

Others	**4**
Headshaking	2
Fever unknown reason	2

Caseload of the equine clinic (division by systems)



General Procedures(*)	**216**
Gastroscopy	12
Respiratory endoscopy	17
Abdominal ultrasound	48
Thoracic ultrasound	10
Thoracic x-ray	8
Abdominal X-ray	3
Bronchoalveolar lavage	7
Tracheal Aspirate	7
Lung biopsy	1
Muscle biopsy	1
Electrocardiography	3
Gasometry	4
Cystoscopy	1
Lameness exam	18
Odontoplasty	30
Echocardiography	10
Computer tomography	7
Tracheostomy	1
Guttural pouch lavage	1
Embryo transfer	1
Magnetic resonance imaging	1
Abdominocentesis	3
Electrocardiography	2
Euthanasia	12
Cecocentesis	1
Thoracocentesis	1
Semen collection	4
Uterine lavage	2

Surgical Procedures	**79**
Vitrectomy	6
Arthroscopy	9
Dental extraction	25
Castration	2
Exploratory laparotomy	15
Orbitotomy (sequestrum)	1
Maxillary sinus flap – bone flap	2
Laringoplasty	2
Laryngeal ventriculectomy	2
Partial mastectomy	1
Amputation coronoid process of the mandible	1
Enucleation	4
Phallectomy	2
Fenestration of the median septum by laser surgical treatment	2
Frontal sinus flap –bone flap	1
Hysterectomy	1
Surgical excision prepuce	1
Coil embolization	1
Thoracic Laparoscopy	1

Total procedures: 295

*they do not include procedures, such as collection of blood, limb bandaging, nerve blocks, regional limb perfusion, intravenous catheter placement, and nasogastric intubation.

LIST OF ABBREVIATIONS

CCA - common carotid artery

ICA - internal carotid artery

ECA - external carotid artery

MA - maxillary artery

CBC - complete blood clount

q12h - every 12 hours

q24h - every 24 hours

i.v. - intravenous

i.m. - intramuscular

kg - kilogram

mm - milimeter

bpm - beats per minute

bpm - breaths per minute

Nd:YAG - neodymium : yttrium-aluminum-garnet

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I. INTRODUCTION

The equine guttural pouches were originally described in Lyon (France), in 1764 by the French veterinarian surgeon Claude Bourgelat, since then their presence has been observed in a wide range of mammals (Pollock 2007). The diseases of the guttural pouches are relatively rare, but several complications are associated with guttural pouch diseases, such as damage to the neural and vascular structures (Fogle *et al.* 2007). The most common diseases of the guttural pouches include empyema, tympany, and mycosis (Hardy *et al*. 2003), where the empyema is the most common disorder that is defined as the presence of purulent material or chondroids (inspissated purulent material) within one or both guttural pouches, and can be responsible for outbreaks of strangles, because the *streptococcus equi* is one of the most common isolated bacteria from guttural pouch empyema (Hardy *et al.* 2003).

Guttural pouch mycosis is considered a rare disease of the upper respiratory system, and a life threatening disease, which approximately 50% of the untreated horses with this disease will suffer a fatal hemorrhage (Sherlock *et al.* 2007). This fatal hemorrhage is caused by fungal erosions usually of the internal carotid artery or as well of the external carotid artery and the maxillary artery (Markus *et al.* 2005). It is recommended to perform arterial occlusion of the affected arteries as soon as possible after the problem is recognized to prevent this fatal epistaxis. In one of the clinical cases, a minimally invasive technique for arterial occlusion is described, because sometimes only through minimally invasive techniques, it is possible to obtain a successful treatment.

Guttural pouch tympany is characterized by a non-painful distension of one or both guttural pouches (Blazyczek *et al.* 2004). Severe distension can cause dyspnea, dysphagia, inhalation pneumonia and secondary empyema (Freeman *et al.* 2012) that make it a life threatening disease. The cause of tympany is unknown, but it has been suggested that abnormal inflation of the guttural pouches can be due to dysfunction of the mucosal fold or malfunction of the pharyngeal musculature (Krebs *et al.* 2007).

II. REVIEW OF LITERATURE

A. ANATOMY

The two guttural pouches of the horse are outpouchings of the Eustachian tubes located in the parotid region, extending from the base of the skull and the atlas bone to the nasopharynx (Lepage *et al.* 2004). They are a bilateral air-filled space with capacity of 300 to 500 ml (Budras *et al*. 2009) and are lined with a ciliated pseudostratified columnar epithelium containing goblet cells (Rush *et al.* 2004). They can be found in *perissodactyls*, such as *equids, tapirs*, some species of *rhinoceros,* some *bats,* a South American forest mouse, and *hyraxes*. The guttural pouches of the horse are the largest of any mammal (Hardy *et al.* 2003).

The guttural pouches are separated from each other on the midline by the rectus capitis ventralis and the longus capitis muscles and the median septum (Freeman *et al.* 2007). The guttural pouch in the rostral part has contact with the basisphenoid bone; in the ventral part with the retropharyngeal lymph node, pharynx, and esophagus; in the caudal part with the atlantooccipital joint; laterally with the digastricus muscle, parotid gland and salivary gland; and dorsally with the petrous part of the temporal bone, tympanic bulla and auditory meatus (Freeman *et al.* 2007).

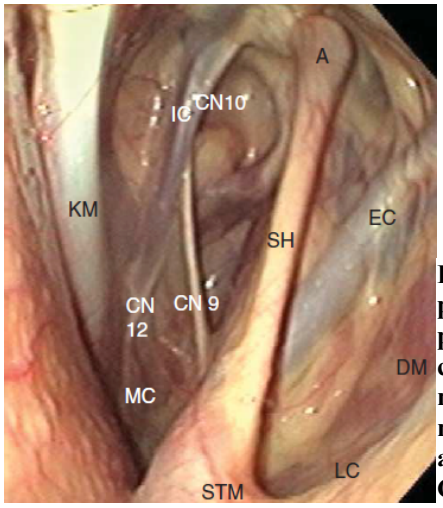

Figure 1: Normal endoscopic anatomy of the left gutural pouch. A, articulation of the stylohyoid bone and the petrous part of the temporal bone; SH, stylohyoid bone; MC, medial compartment; LC, lateral compartment; DM, digastricus muscle; KM, long capitis muscle; STM, stylopharyngeus muscle; EC, external carotid artery; IC, internal carotid artery; CN9, glossopharyngeal nerve; CN10, vagus nerve; CN12, hypoglossal nerve. (Adapted from Seahorn 2004)

Each guttural pouch is divided ventrally into a medial and a lateral compartment by the stylohyoid bone (Barakzai 2007), this bone that makes part of the hyoid apparatus, articulates dorsally with petrous temporal bone and ventrally with keratohyoid bone (Barakzai 2007). The lateral compartment is approximately one third of the capacity of the medial compartment, whereas the medial compartment extends more caudally and

ventrally (Seahorn 2004). Each guttural pouch communicates with the pharynx through the pharyngeal orifice of the Eustachian tube, the pharyngeal orifice is a funnel-shaped opening in the dorso-lateral wall of the pharynx that forms an oblique slit rostral and ventral to the dorsal pharyngeal recess (Freeman *et al.* 2012), the medial lamina of the pharyngeal opening is composed of fibrocartilage directed in a rostroventral-to-caudodorsal direction (Freeman *et al.* 2012). This fibrocartilage supports the oblique slit (Sherlock *et al.* 2007).

Diseases of the guttural pouches normally are manifested when damage of the epithelium occurs, allowing disruption of the underlying neural, vascular and lymphoid structures (Sherlock *et al.* 2007).

The medial compartment is in contact with the internal carotid artery, cranial cervical ganglion, cervical sympathetic trunk, the glossopharyngeal, the vagus, the hypoglossal and spinal accessory nerves (Freeman *et al.* 2012). All of these structures are contained in the mucosal fold along the caudal wall of the medial compartment. In the ventral part of the medial compartment overlie the retropharyngeal lymph nodes, the pharyngeal branch of the vagus and the recurrent laryngeal nerve (Hardy et al. 2003).

In the lateral compartment, the external carotid artery lies along of the wall and gives off the auricular artery and superficial temporal artery, and it continues as the maxillary artery along the roof of the guttural pouch (Freeman *et al.* 2012). The facial nerve that emerges from the stylomastoid foramen, passes for a short distance over the caudodorsal aspect of the lateral compartment. The vestibulocochlear nerve that enters in the internal acoustic meatus, innervate components of the middle ear, is a nerve that doesn't enter in the guttural pouch but can be damaged in diseases of the guttural that affect the middle ear. The mandibular nerve (branch of the trigeminal nerve) emerges from the foramen lacerum and passes along the roof of the lateral compartment of the guttural pouch (Freeman *et al.* 2012). The cranial nerves V, VII, VIII, IX, X, XI and XII can be affected by diseases of the guttural pouch, as well as the maxillary artery, internal and external carotid arteries that provide the major blood supply to the head.

B. FUNCTION

Function proposal	Reference
Voice resonating chamber	Girard (1807)
Air cushions	Prange (1853)
Aid in clearing the nasal cavity	Rudinger (1870)
Buoyancy device	Muller (1885)
Assist hearing	Vermeulen (1909)
Modify inspiratory air pressure and temperature	Fish (1910)
Assist swallowing	Skoda (1911)
Increase head mobility	Richter (1923)
Simply to fill space	Schmaltz (1928)
Aid regurgitation	Gratzl (1944)
Source of pharyngeal mucous	Baker (1984)
Regulate cerebral arterial blood pressure	Smallwood (1992)

Table 1: Several functions proposed for the equine guttural pouch since the first description in 1756 by Claude Bourgelat (Adapted from Baptiste, 1998)

Several functions were attributed to the guttural pouches, including pressure equilibration across the tympanic membrane, contribution to air warming, a resonating air chamber for the equine whinny and flotation device (Hardy *et al*. 2003).

In one study performed by K. E. Baptiste, the measurements showed a lower arterial temperature in the cerebral side of the Internal carotid artery compared with the cardiac side (Baptiste 1998), even when just a single portion of the internal carotid artery (13 cm) is exposed on the wall of the guttural pouch. The results of this study, suggest that horses could use the guttural pouches to cool internal carotid artery blood that is destined for the brain, as brain cooling, is the more recently proposed function (Baptiste 1998).

Another study from K. E. Baptiste showed that opening of the pharyngeal orifice of the guttural pouch occurs in two different ways, active and passive. In the active process, opening of the pharyngeal orifices by simultaneous contractions of the levator and tensor veli palatine, and pterygopharyngeus muscles, then opening of the pouch ostia by contractions of dorsal portions of the palatopharyngeus muscles. The passive opening of the auditory tube involves reduction in tone of the stylopharyngeus and pterygopharyngeus muscles, accompanied by increased inspiratory pressure (Baptiste 1997). This study demonstrated that is in the inspiration that occurs the guttural pouch filling (Baptiste 1997).

C. DISEASES OF THE GUTTURAL POUCHES

Tympany

The guttural pouch tympany is a rare condition that develops in foals in the first weeks of life and up to 1 year of age (Freeman *et al.* 2012). This disease is characterized by an increased air content of one or both guttural pouches (Zeitz *et al.* 2009). This condition is reported to be more frequent as unilateral than bilateral (Freeman *et al.* 2012). A retrospective study in the equine clinic of the University Veterinary Medicine of Hanover on 50 foals during 7 years, showed that fillies are more commonly affected than colts, where the ratio of affected colts to fillies was 1:2.92 (approximately 3 times more in fillies than colts). The result of this study was similar to the previous observations (Blazyczek *et al*. 2004). Breed and sex of foals didn't affect the age of onset, type and severity of clinical signs or rate of recurrence (Blazyczek *et al.* 2004).

In one study performed in 27 Arabian purebred horses to analyze the mode of inheritance of guttural pouch tympany in the Arabian horse, complex segregation analyses were employed to test for the significance of nongenetic transmission and for monogenetic, polygenic, and mixed monogenic-polygenic modes of inheritance. The complex segregation analyses showed that a polygenic and mixed monogenic-polygenic model best explained the segregation of Arabian foals with guttural pouch tympany (Blazyczek *et al.* 2004).

A whole-genome scan for guttural pouch tympany in 143 horses from five Arabian and five German Warmblood families indicated sex-specific quantitative trait locus, is in agreement with the higher prevalence in females (Zeitz *et al.* 2009).

The etiology of tympany is still not clear but possible causes for its occurence is the fact that mucosal flap or plica salpingopharyngea acts as a one-way valve, allowing air to enter but not to exit (Krebs *et al.* 2007), may be due either to the presence of abnormally large mucosal folds or to a dysfunction of the mucosal flap at the pharyngeal orifice (Blazyczek *et al.* 2004). Inflammation from an upper airway infection, persistent coughing and muscle dysfunction have been proposed as alternative causes (Rush *et al.* 2004). In the majority of the cases is not possible to find any anatomic abnormality at the guttural pouch opening or adjacent structures (Blazyczek *et al*. 2004).

Empyema

The guttural pouch empyema is defined as the presence of purulent material, and chondroids inside of one or both the guttural pouches (Freeman *et al*. 2007). The chondroids are concretions of inspissated pus that could be a sequela of the chronic cases of guttural pouch empyema (Adkins *et al.* 1997). These concretions are hard, spherical or ovoid (Perkins *et al.* 2007). This pathology can affect horses of any age but usually the younger ones (Freeman *et al.* 2007) and is frequently related as a result of an upper airway infection especially caused by Streptococcus spp., which can extend into the guttural pouch and cause empyema (Hardy et al. 2003). Other causes that can originate guttural pouch empyema are abcessation and rupture of retropharyngeal lymph nodes, infusion of irritant drugs, fracture of stylohyoid bone, pharyngeal perforation using a nasogastric tube and congenital or acquired stenosis of the pharyngeal opening (Freeman *et al.* 2007). In one study of 91 horses with guttural pouch empyema over a span of 20 years, 21% of the horses had chondroids. The Retropharyngeal swelling and pharyngeal narrowing were significantly more prevalent in horses with chondroids (Judy *et al.* 1999).

Guttural pouch mycosis

Guttural pouch mycosis was described for the first time by Rivolta in 1868 that named the fungus the *Gutturomyces equi* and confirmed the presence of *Aspergillus spp.* fungus because of the appearance and type of lesion (Pollock 2007).

The cause of guttural pouch mycosis is unknown, *Aspergillus spp* can be observed in the lesion and the *Aspergillus fumigatus* is the most isolated specie (Freeman *et al.* 2007). In one retrospective study in 21 cases of guttural pouch mycosis in horses between 1998-2002, the fungal identification was positive in 87% of these cases, in which the *Aspergillus spp*. was involved in the majority of the cases (13 cases) and the *Aspergillus fumigatus* was the most identified specie, through this study it was possible to observe that *Aspergillus fumigatus* is more likely to be found by direct examination than by fungal culture (Ludwig *et al.* 2005). The mechanism through which *Aspergillus spp.,* a normal inhabitant of the equine upper airway and environment, can become a pathogen in animals that are not debilitated or immunosuppressed is not understood (Pollock 2007).

There is no apparent age, gender, breed, or geographical predisposition for this disease that can affect foals and appears to be more related with stabled horses during the

warmer months of the year (Rush *et al.* 2004).

Guttural pouch mycosis usually affects one guttural pouch, rarely both (Freeman *et al.* 2007), the lesions consist of diphtheritic plaques of variable size, composed of necrotic tissue, cell debris, a variety of bacteria and fungal mycelia (Rush *et al.* 2004).

D. CLINICAL SIGNS

Tympany

Distension of the affected guttural pouch with air, where the swelling is nonpainful, soft, compressible and elastic in the parotid region (Rush *et al.* 2004). The unilateral swelling can extend across the neck and give the impression of bilateral involvement (Freeman *et al.* 2012). Severe swelling in some cases can cause stridorous breathing, dyspnea, coughing, dysphagia and inhalation pneumonia and secondary empyema (Freeman *et al.* 2012).

Empyema

The clinical signs of empyema include intermittent purulent nasal discharge that is commonly observed at rest and when the horse is eating, because the drainage is facilitated when the horse lowers the head (Hardy *et al.* 2003), swelling of the parotid region, pain of the parotid region, and in some cases fever. The distension of the affected pouch into the pharynx can produce dyspnea and an abnormal respiratory noise (Rush *et al*. 2004). In cases of chronic empyema signs of cranial nerve involvement can be observed, such as dysphagia, laryngeal hemiplegia and persistent soft palate displacement (Hardy *et al*. 2003). These clinical signs are not common with this disease but can persist in some cases after successful resolution of the empyema (Freeman *et al.* 2012). This disease can have a bilateral involvement (Freeman *et al.* 2012).

Guttural pouch mycosis

Moderate to severe epistaxis not associated with exercise is the most common clinical sign, that is caused by fungal erosion of the wall of the internal carotid artery in most cases and of the external carotid artery and maxillary artery in one third of cases (Pollock 2007). Any branch of the external carotid artery, such as the caudal auricular artery, can be affected (Freeman et al. 2007). Severe episodes of hemorrhage usually precede a fatal episode (Freeman *et al.* 2007). In the first instance the epistaxis consists of a small quantity of fresh blood at one nostril, mucus and dark blood may continue to

drain from the nostril on the affected side for several days after acute hemorrhage ceases (Rush *et al.* 2004). The second most common clinical sign is dysphagia caused by damage to the glossopharyngeal nerve and the pharyngeal branch of the vagus nerve, which in severe cases aspiration pneumonia can develop (Pollock 2007). In some cases, affected horses may present abnormal respiratory noise, which can occur from pharyngeal paresis or laryngeal hemiplegia - (the last one is present when damage of recurrent laryngeal nerve occurs) (Pollock 2007). When damage to the cranial cervical ganglion and postganglionic sympathetic fibers occurs, Horner's syndrome may develop. The clinical signs associated with this syndrome are ptosis, miosis, enophthalmos, patchy cervical sweating and congestion of the nasal mucosa (Freeman *et al.* 2012). Clinical signs less commonly associated with guttural pouch mycosis include facial nerve paralysis, paralysis of the tongue, abnormal head carriage, head-shaking, locomotion disturbances, sweating, colic, exposure keratitis and corneal ulceration, blindness, parotid pain, infection of the middle ear, osteites of the stylohyoid and petrous temporal bones or arthropathy of the atlanto-occipital joint (Pollock 2007).

E. DIAGNOSIS

Tympany

The diagnosis is based largely on the clinical signs (Freeman *et al.* 2012). The tympany produces a swelling in the parotid region that can be palpated externally (Rush *et al.* 2004).

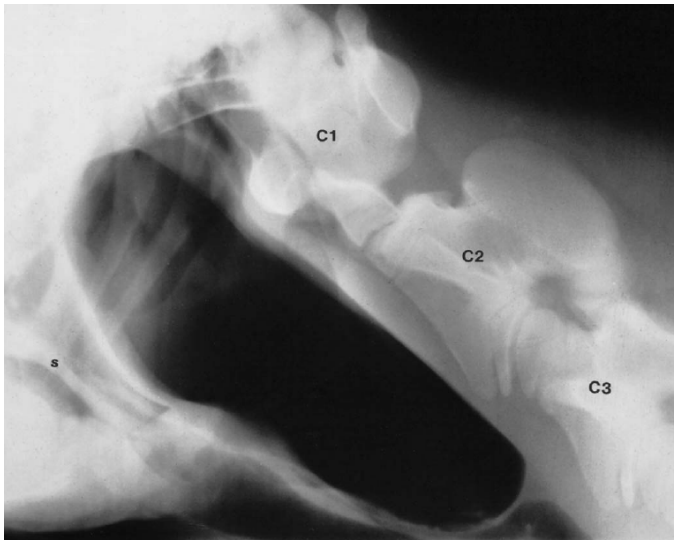

Figure 2: lateral radiograph of the pharyngeal region of a foal with gutural pouch tympany showing distension with gas of the guttural pouch (Adapted from Butler et al. 2000).

In the lateral radiographs is possible to observe distension with gas of the guttural pouch that may extend to the level of the middle of the third cervical vertebra (Butler *et al.*

2000). The distended pouch can cause compression of the pharynx, the larynx and proximal trachea may be displaced (Rush *et al.* 2004). When there is accumulation of milk (in case of the foals) or exudate in the guttural pouch, the air-fluid interfaces may be visible in guttural pouch (Rush *et al.* 2004). The differentiation between unilateral or bilateral tympany is not easily established using x-ray (Freeman *et al*. 2012). On endoscopic examination, the dorsal pharyngeal wall can be collapsed, and the pharyngeal openings usually show a normal appearance (Hardy *et al.* 2003) and by endoscopy is possible to know which pouch is more affected through the median septum bulging, the median septum will be bulging into the less affected pouch (Ohnesorge *et al.* 2012). In foals that have history of coughing or dysphagia, it is recommended to perform an endoscopy of the trachea, to confirm if aspiration of milk or feed material has occurred (Rush *et al*. 2004).

Empyema

On endoscopic examination frequently demonstrates mucopurulent exudate draining from the pharyngeal orifice of the affected pouch (Rush *et al.* 2004). On lateral radiographs it is possible to observe the loss of air contrast within the guttural pouch and an air/fluid interface will be demonstrated if the purulent material is still fluid (Rush *et al.* 2004). This fluid can be accompanied by masses seen inside the guttural pouches that suggest the presence of chondroids (Freeman *et al.* 2007). In both situations there is an increased radiopacity. The saline washings or aspiration of the fluids from the affected guttural pouch can be taken for culture or sensitivity testing, but results should be interpreted with caution because microorganisms can be obtained from the normal guttural pouch and upper respiratory tract (Freeman *et al.* 2007). A high correlation exists between the cytologic score and the presence of pathogenic bacteria, such as *Streptococus equi* (Freeman *et al.* 2007). Less than 5% neutrophils is considered a normal cytologic pattern and greater than 25% is considered abnormal (Freeman *et al.* 2007).

Guttural pouch mycosis

Diagnosis of guttural pouch mycosis is usually based on history, clinical signs and endoscopy examination of the pharynx and guttural pouches. On endoscopic examination of a horse with epistaxis, is possible to observe blood or mucus draining from the pharyngeal office of the affected guttural pouch (Rush *et al.* 2004).

In horses with clinical signs of dysphagia, the nasopharynx may contain food material, the dorsal wall of the pharynx can be collapsed, and the soft palate can be displaced (Freeman *et al.* 2012). Laryngeal hemiplegia can be observed by damage the laryngeal recurrent nerve (Hardy *et al.* 2003).

When the endoscopy is performed in the affected guttural pouch, the mycotic lesion usually appears as a white, brown and black diphtheritic membrane on the roof of the guttural pouch, where the size and the appearance can be variable but without relationship to the severity of the clinical signs (Freeman *et al.* 2012). If a recent hemorrhage has occurred it may be difficult to identify any structures within the pouch and may be impossible to accurately locate the lesion or identificate the damaged vessel (Pollock 2007). In some cases, the stylohyoid bone can be coated with a diphtheritic membrane and the bone can be thickened, but clinical signs usually are not related with this finding (Freeman *et al.* 2012).

In all cases of mycosis, the contralateral guttural pouch should be examined, since fistulas may form through the medial septum and for concurrent bilateral mycosis (Rush *et al.* 2004). In one study performed in 31 horses with guttural pouch mycosis between 1999-2002, 6 horses had a bilateral involvement (Lepage *et al.* 2005).

The presence of serum antibodies to Aspergillus spp. detected by ELISA cannot be used to differentiate between healthy horses and horses with guttural pouch mycosis (Freeman *et al.* 2012).

Angiography can be used to demonstrate aneurysms of the internal carotid artery, external carotid artery or maxilar artery, or when is not possible to make the identification of the damage vessel using another means before to the surgery (Rush *et al.* 2004).

F. TREATMENT

Tympany

The goal of treatment for guttural pouch tympany is to establish a permanent means for allowing air to escape from the affected guttural pouch or pouches (Freeman *et al.* 2006). Temporary alleviation of guttural pouch tympany can be achieved by placing an indwelling catheter in the pharyngeal office or by needle decompression (Freeman *et al.* 2012).

The conservative treatment by decompression using an indwelling guttural pouch catheter in the pharyngeal orifice during 2 to 3 weeks, with antibiotics and anti-

inflammatory drugs, is a controversial treatment, since it was reported that it can lead to the development of empyema, bronchopneumonia (Schambourg *et al*. 2006) and permanent deformity and scarring in the cartilage of the pharyngeal ostium induced by several weeks of continuous catheterization (Freeman *et al.* 2012).

Surgical intervention is used for provide a permanent means of evacuating air (Freeman et al. 2012). Diverse procedures can be used, such as fenestration of the median septum, removal of the obstructing membrane or creation of salpingopharyngeal fistulas (Freeman *et al.* 2012). The median septum between the pouches can be fenestrated through Viborg's triangle approach or through a modified Whitehouse approach. The latter has been described to be associated with better results. The median septum can be fenestrated by removal of a $2cm^2$ segment that allows the air to leave the abnormal guttural pouch through the normal side (Rush *et al.* 2004). A Chamber´s mare catheter or lighted fiberoptic endoscope should be used for insertion into the healthy pouch and to elevate the septum toward the incision and to facilitate the identification of an area free of vessels or nerves (Freeman *et al.* 2012). This procedure is effective just in unilateral cases of tympany, in which bilateral involvement is suspected. The fenestration of the median septum can be combined with the removal of a small segment (1.5 cm x 2.5 cm) of the medial lamina of the Eustachian tube or/and associated mucosal fold (plica salpingopharyngea) within the guttural pouch orifice. This forms a larger pharyngeal orifice (Freeman *et al.* 2012). Serious complications associated with these open surgical approaches due iatrogenic nerve damage are reported (Hardy *et al.* 2003).

Minimally invasive techniques can be used for fenestration of the median septum and partial resection of the medial lamina trough transendoscopic laser surgery with high-powered diode or a neodymium:yttrium-aluminum-garnet (Nd:YAG) laser or transendoscopic electrosurgery (Freeman et al. 2012). These minimally invasive techniques can be used to create the salpingopharyngeal fistulas. The fistula is created between the tympanic pouch and the pharyngeal recess and, the location of the fistula is dorsocaudal to the guttural pouch ostium, a foley catheter should be placed in the fistula 14 days (Rush *et al.* 2004), to prevent closure of the fistula and for the fistula to mature (Freeman *et al.* 2012). This treatment could possibly disturb upper airway dynamics in the athletic horse (Hawkins *et al.* 2001). These minimally invasive techniques can be

performed as a standing procedure, which avoids general anesthesia and recovery complications.

Empyema

The treatment can be achieved in acute cases by the insertion an indwelling foley catheter or coiled polyurethane guttural pouch catheter into the pouch (Barakzai 2007), daily lavage should be performed with normal saline or a dilute antiseptic solution such as 1% povidone-iodine for 7-10 days (Rush *et al.* 2004), another option is flushing of the guttural pouch through the biopsy channel of the endoscope, which has the advantage of delivery flush solution in the areas covered with purulent material (Freeman *et al.* 2007). The goal of this lavage is to dislodge and remove mucopurulent material from the guttural pouch that produces a more favorable environment for recovery, concentrated antiseptic solutions or hydrogen peroxide shouldn´t be used because they are irritating and can induce inflammation of the mucosa and neuritis of the cranial nerves (Freeman *et al.* 2012). The use of the topical antibiotics solutions showed a low efficacy because the contact period is too brief and they can be inactivated by the products of the inflammation present in the purulent material (Freeman *et al.* 2012). The efficacy or necessity of the treatment with systemic antibiotics is undefined. They can be indicated when the horse is dysphagic, and to prevent or treat aspiration pneumonia (Rush *et al.* 2004). In one horse with empyema the use of acetylcysteine solution on 4 occasions appeared to accelerate the resolution of the problem, but this mucolytic agent doesn't have the ability to alter the viscosity of purulent material in clot tube when compared with the use of saline alone, and it is an irritant solution (Freeman *et al.* 2012).

Figure 3: removal of a guttural pouch chondroid with an endoscopically guided snare (Perkins et al. 2007)

The inspissated exudate (chondroids) can be removed from the guttural pouch by maceration, followed by saline lavage when in small quantities and with consistency of cottage cheese (Perkins *et al.* 2007). When the chondroids are small in diameter they can be removed with an endoscopically guided snare or when they are large, they can be cut in small pieces with a snare. The small pieces are then removed by lavage or extraction by basket-type endoscopic forceps (Perkins *et al.* 2007). These noninvasive methods can be a successful treatment but some procedures can take 8 hours over 4 days (Perkins *et al.* 2007). Chronic empyema of the guttural pouch that is unresponsive to the medical therapy can be solved through fistulation of the guttural pouch by using a laser to establish a permanent pharyngeal fistula into the guttural pouch (Hawkins *et al.* 2001). The inspissated exudate has to be removed surgically when nonsurgical removal has failed. After the surgery, the incision of the surgical approach should be left open to drain and to allow repeated lavage of the pouch (Freeman *et al.* 2012). In one pony with chondroids and obstruction of the pharyngeal ostium on the affected side by deformity and fibrotic adhesion, transendoscopic laser Nd:YAG fenestration of the median septum was performed from the healthy guttural pouch and the multiple chondroids were removed using grasping and basket-type forceps (Gehlen *et al*. 2005).

Guttural pouch mycosis

Nonsurgical treatment

The response to topical treatment is usually slow and inconsistent, and doesn't prevent the risk of fatal hemorrhage as with the surgical occlusion of the affected artery (Rush *et al.* 2004). Nevertheless, the medical treatment can be an effective option when the fungal plaque does not involve a blood vessel and/or exist financial restraints (Pollock 2007). The medical treatment can consist in daily direct lavage through the endoscope that can macerate the diphtheritic membrane and the use of biopsy forceps or cytology brush for detachment of the diphtheritic membrane (Freeman *et al.* 2007). Topical povidone-iodine or thiabendazole with or without dimethyl sulfoxide, has been used in the medical treatment of mycotic lesions with mixed results. Other antifungals such as nystatin, natamycin and miconazole have little activity against *Aspergillus spp*.. Amphotericin B can be effective against *Aspergillus spp*, but systemic treatment in the horse is limited by the high cost of antifungal drugs and by its toxicity (Freeman *et al.* 2007). Itraconazole at 3 mg/kg twice a day in the feed is effective against *Aspergillus* and other fungi in the nasal cavity, but this treatment can take up to 4 or 5 months

(Freeman *et al.* 2012). During any medical treatment there is a risk of bleeding (Hardy *et al.* 2003). Horses with blood loss can be treated with polyionic fluids or with blood transfusions if they need. Horses that are dysphagic should be fed by nasogastric tube or by esophagostomy and they can receive nonsteirodal anti-inflammatory drugs to reduce neuritis (Freeman *et al.* 2007).

Surgical treatment

Several surgical options have been described for the treatment of guttural pouch mycosis, especially for horses with signs of epistaxis and for horses with mycotic lesions overlying the blood vessels (Pollock 2007). The surgical removal of the diphtheritic membrane by gentle swabbing and lavage through a modified Whitehouse approach is not recommended, this treatment does not eliminate the risk of hemorrhage and does not retard the progression of the neurological signs but it can lead to a fatal hemorrhage and iatrogenic nerve damage (Freeman *et al.* 2007).

When surgical occlusion of the affected artery is performed, there is some evidence that it leads to a spontaneous resolution of the mycotic lesion without any medical treatment (Freeman *et al.* 2012). When the horse presents hemorrhage caused by guttural pouch mycosis, one of the described procedures or combination of them should be used for arterial occlusion, as soon as the diagnosis is made (Freeman *et al.* 2007). The vessel that needs to be occluded can be identified by endoscopy, if is not possible to make an accurate identification of the vessel, all arteries inside of the guttural pouch should be occluded (Freeman *et al.* 2007). The arteriography can be used to determine the affected vessel or aberrant anatomy (Freeman *et al.* 2007).

Procedures for arterial occlusion

Ligation of the common carotid artery and branches

Ligation of the common carotid artery on the affected side is an emergency procedure that can be performed with the horse standing or under general anesthesia (Hardy *et al.* 2003). This procedure can prevent hemorrhage from the ICA, but it does not prevent the retrograde flow from the arterial cerebral circle (circle of Willis) or from the collateral vessels (Hardy *et al.* 2003). In one study performed in six anesthetized horses to know the effects of selective arterial occlusion on blood flow through the CCA and its branches, showed that occlusion of the ipsilateral CCA increased the retrograde flow in the ICA, making this procedure contraindicated for control the bleeding from the ICA

(Freeman *et al.* 2012). The bilateral occlusion of the CCA or the ipsilateral occlusion of the ICA can be used for acute control of ICA hemorrhage (Hardy *et al.* 2003). In this study the bilateral occlusion of the CCA showed better results in the reduction of the retrograde flow in the ICA than the ipsilateral ICA occlusion (Freeman *et al.* 2012). The basilar artery is the main blood supply to the brain, in this way the occlusion of the both ICA or both CCA can be performed without risk of cerebral ischemia (Rush *et al.* 2004). When a horse is bleeding from the ECA or its branches, the occlusion of either one or both CCAs, the occlusion of the ipsilateral CCA rostral to the ICA bifurcation, the occlusion of the ECA, the occlusion of the major palatine artery and CCA or ECA reduce the flow in the ECA. Any of these procedures can reduce the ECA flow and produce an immediate benefit but this benefit could be temporary (Hardy *et al.* 2003). A double ligation of the ICA in the proximal and distal side of the lesion has been described, but taking into account the degree of difficulty to perform these ligations and high rate of complications, such as rupture of the vessels (including fatal hemorrhage) or severe damage of the cranial nerves, this treatment has been abandoned (Hardy et al. 2003).

Balloon catheter occlusion

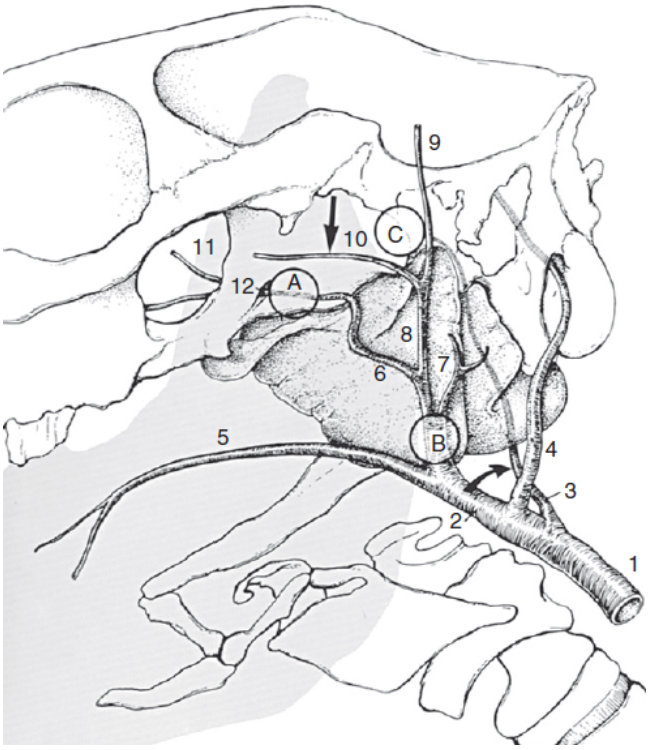

Figure 4: arteries close to and underlying the mucosa of the guttural pouch (numbers) and sites of balloon catheter occlusion (letters); 1, common carotid artery; 2, external carotid artery; 3, internal carotid artery; 4, occipital artery; 5, linguofacial artery; 6, maxillary artery; 7, caudal auricular artery; 8, superficial temporal artery; 9, rostral auricular artery; 10, transverse facial artery; 11; external ophthalmic artery; 12, caudal alar foramen;
A-occlusion of the MA, the balloon is inserted in the major palatine artery and guided in retrograde fashion to be inflated immediately caudal to the caudal alar foramen; B-occlusion of the ECA, the balloon is inserted into the transverse facial artery (10) at the arrow and is directed into the ECA, where it is inflated close to the floor of the guttural pouch; C-occlusion of the ICA, balloon in the ICA at the sigmoid flexure, dorsal to the roof of the guttural pouch. This catheter is inserted into the ICA (3) at the arrow (adapted from Freeman *et al.* 2012).

The balloon tipped catheter technique allows immediate intravascular occlusion of the affected artery and prevents retrograde flow to the site of hemorrhage from the cerebral arterial circle (Freeman *et al.* 2007). This procedure can be an effective method to prevent a fatal hemorrhage when the catheters are correctly placed and there is no aberrant vascular anatomy (Hardy et al. 2003). After the arterial occlusion there is formation of thrombus within the affected arteries some days after performing the occlusion (Hardy *et al.* 2003). The placement of the balloon catheter in the internal carotid artery is technically easier when compared with placing a catheter into the ECA and MA (Hardy *et al.* 2003). In the balloon catheter technique for occlusion of the ICA, the ICA is ligated close to its origin, and an arteriotomy is performed distal to the ligature. A 6-French venous thrombectomy catheter is inserted into ICA and, the catheter is advanced approximately 13 cm to occlude the artery distal to the mycotic lesion (Rush *et al.* 2004). At this distance, the balloon tip of the catheter is arrested at the sigmoid flexure of the ICA (Freeman *et al. 2012*). The balloon is inflated with sterile saline, secured in position by a ligature distal to the arteriotomy and the redundant part of the catheter is buried as the incision is closed (Freeman *et al.* 2012). The procedure does not need fluoroscopy to confirm the placement of the catheter but intraoperative endoscopy could very helpful for identification of the arteries (Freeman *et al.* 2012).

The occlusion of ECA and MA requires a different approach from ICA, because several collateral vessels are present and so it can result in retrograde flow to the lesion. The major palatine artery is the most likely source of retrograde flow to the ECA and its branches (Rush *et al.* 2004). The ECA is ligated after the linguofacial trunk branches, and the occlusion of the MA is performed via an arteriotomy of the major palatine artery through the oral cavity, 3 cm caudal to the corner the incisor tooth, through which a 6-French Fogarty venous thrombectomy catheter is inserted (Hardy *et al.* 2003). The catheter is advanced distally for a distance of 40-42 cm in a 450 kg horse and, the balloon is inflated in the maxillary artery immediately caudal to the caudal alar foramen (Rush et al. 2004). At this site the balloon can obstruct the retrograde flow to the MA (Freeman *et al.* 2012). As an alternative to ligation, the ECA can be occluded distal to the origin of the linguofacial trunk. The balloon catheter is inserted approximately 12 cm into the tranverse facial artery in a 450 Kg horse, at 3 cm rostral to the articular tubercle of the temporal bone and advanced in retrograde fashion until its tip enters the

ECA, where the balloon is inflated with saline (Rush *et al.* 2004). In these approaches for occlusion of the MA and the ECA, the redundant end of the catheter is taped to the head or incorporated into a stockinette hood (Freeman *et al.* 2012). These catheters are removed after a period of 7 to 10 days post-surgery without sedation or local anesthesia (Hardy *et al.* 2003), as opposed to the occlusion of the ICA, where the catheter is usually left in place. When occlusion of the ECA and its branches is performed there is the risk of blindness in all procedures, as a result of ischemic optic neuropathy (Hardy *et al.* 2003). The owner should be warned even when the risk is very low.

Some complications are related with the use of balloon-tipped catheters such as incisional infection that should be treated by removal of the catheter and establishing drainage (it can be avoided by inflating the balloon to a sufficient diameter to prevent displacement into the affected segment), breakage of the catheter when it is removed, foreign body reactions, retrograde infection and, one horse has developed a septic meningitis that could be prevented by removal of the catheter when signs of infection were evident. Other complications are the recurrent epistaxis or failure to prevent a fatal hemorrhage that could be caused by an inappropriate catheter placement or occlusion of an aberrant branch, leaving the affected segment of the artery open to retrograde flow, requiring a second surgery (Freeman *et al.* 2012).

The occlusion of the ICA with a detachable balloon catheter system

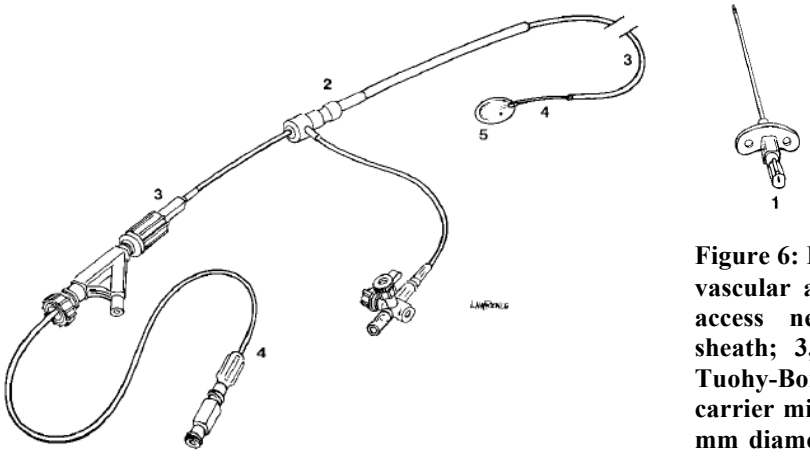

Figure 6: Balloon delivery system and vascular access. 1, 19-gauge arterial access needle; 2, 8-F introducer sheath; 3, 8-F guide catheter with Tuohy-Borst adapter; 4, balloon carrier microcatheter; 5, inflated 8.5-mm diameter balloon (Adapted from Cheramie et al. 1999).

Occlusion of the ICA with an intravascular, detachable, self-sealing, latex balloon distally and proximal ligation was described as a successful technique. This technique does not require the catheter removal and can be used for occlusion of aberrant vessels

(Cheramie *et al.* 1999). The origin of the affected ICA is isolated between two Rumel tourniquet of umbilical tape and polyethylene tubing. One Rumel tourniquet is placed near the origin of the ICA and the second one is placed approximately 3 cm distal to the first (Cheramie *et al.* 1999). The balloon delivery system consists of a Tuohy-borst adapter that is attached to an 8-French, 95 cm nontapered, thin-walled guiding catheter. A 2-French, 135 cm balloon-carrier microcatheter is placed through the adapter and guiding catheter, and an 8.5 mm diameter, detachable, self-sealing, latex balloon inflated with 0.5 ml of a 1:1 solution of physiologic saline solution and iothalamate sodium 66.8% is mounted onto the carrier microcatheter (Cheramie *et al.* 1999). Once mounted, the balloon is deflated. The carrier microcatheter is withdrawn so that the balloon is recessed 2 mm inside the guiding catheter and the microcatheter is held in place by tightening the O-ring of the Tuohy-Borst adapter (Cheramie *et al.* 1999). A 19-gauge arterial access needle is inserted into the artery between the two tourniquets and a 0.9 mm guide wire is placed through the needle into the artery. The needle is withdrawn over the wire and an 8-French introducer sheath with dilator in place is advanced 4 cm over the wire into the vessel. Then the dilator and wire are removed and the retrograde flow from the cerebral arterial circle is confirmed by bleed-back through the ancillary fluid port of the introducer sheath (Cheramie *et al.* 1999).

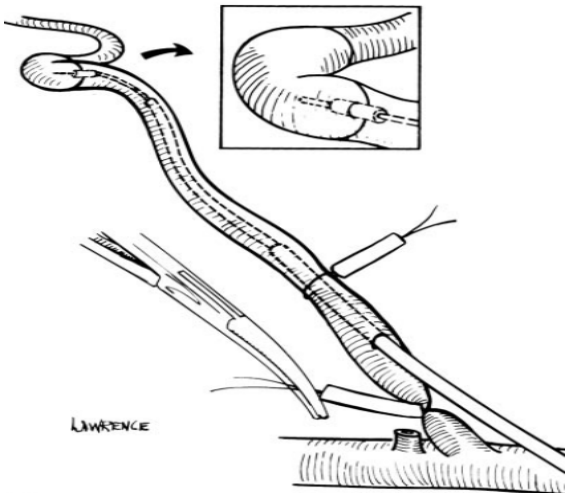

Figure 7: inflation of the balloon within the proximal bend of the sigmoid flexure of the ICA, through the balloon delivery system (Adapted from Cheramie et al. 1999).

The balloon delivery system is introduced into the ICA through the flexible diaphragm of the introducer sheath and advanced 13 cm until the resistance is met (proximal bend of the sigmoid flexure of the ICA). The carrier microcatheter is advanced 5 to 10 mm within the guiding catheter while the guiding catheter is retracted 1 cm over the microcatheter. The balloon is then inflated with 0.5 ml of a radiopaque solution, which the correct placement and inflation of the balloon can be confirmed by intraoperative

radiography (Cheramie *et al.* 1999). The balloon is then released and the guiding catheter and carrier microcatheter are withdrawn from the introducer sheath and immediate occlusion of the distal ICA is confirmed by lack of retrograde blood flow through the introducer sheath. The introducer sheath is removed from the vessel and the proximal Rummel tourniquet is replaced with two ligatures of No.0 polypropylene. The subcutaneous tissues and the skin are closed in layers (Cheramie *et al.* 1999). This technique was not reported in the occlusion of the ECA and its branches in horses (Freeman *et al.* 2012).

Transarterial coil embolization

The transarterial coil embolization is a recent technique using Dacron fibre-covered stainless steel spring embolization coils to occlude both sides of an arterial defect of any type of artery implicated in guttural pouch mycosis (Lepage *et al.* 2005). The stainless steel coil of an appropriate size is placed within the artery, and the Dacron fibers on its surface induce rapid thrombosis in the occluded segment (Freeman *et al.* 2012). This technique combines angiographic studies to visualize the affected vessel or any unusual vessels and sites of bleeding with selective embolization or occlusion of the affected vessel (Hardy *et al.* 2003). When compared to the balloon catheter technique, the transarterial coil embolization allows visualization of the affected vessels throughout the procedure because it is performed under fluoroscopic guidance, that allows to identify aberrant branches. No identification and occlusion of these aberrant branches may result in fatal hemorrhage and cerebral lesions (Hardy *et al.* 2003). It can be performed during active bleeding. It does not require to protect redundant ends of catheters necessary when nondetachable balloons are used. It is less invasive and requires a shorter period of anesthesia and hospitalization (Freeman *et al.* 2012). Under general anesthesia, the horse is placed in lateral recumbency, and the head and neck is placed on radiolucent surface, with the affected side uppermost. The proximal aspect of the jugular groove is clipped, prepared for aseptic surgery and draped (Freeman *et al.* 2012). A single surgical approach is sufficient to allow access to all branches of the CCA, such as the ICA, the ECA, the MA, and small branches under fluoroscopic guidance (Hardy *et al.* 2003). Generally, the occlusion of all branches is performed in cases in which the lesions are extensive or when preoperative hemorrhage precludes identification of the affected artery (Freeman *et al.* 2012). An 8-cm skin incision is made at the junction of the proximal and middle third of the neck just dorsal to the

jugular vein. The brachiocephalicus and omohyoid muscles are bluntly separated, and the carotid sheath is elevated by blunt finger dissection. The CCA is separated from the vagosympathetic trunk, elevated with umbilical tape or two Penrose drains, and punctured with an angiographic needle (Hardy *et al.* 2003). A 6-French introducer system is inserted in the artery and guided toward the head. A 6-French, single end-hole, nylon angiographic catheter is inserted rostrally into the CCA to the level of the ICA using fluoroscopic guidance. An angiogram is performed by hand injection of 10 to 20 ml of iohexol in heparinized physiological saline solution (1:2 ratio) to identify the branches of the CCA and to estimate the diameter of each branch (Hardy *et al.* 2003). Preembolization angiography is mandatory before embolization for anatomic identification of the vessels, exclusion of vascular anomalies, and correct positioning of the embolization coils. The aberrant arterial branches are present in up to one third of horses and require selective embolization. The diameter of the coil can be estimated by the width of the artery at the embolization site, and is made by using the known 3 mm diameter of the angiographic catheter as guide (Freeman *et al.* 2012). The ICA is the first artery embolized at the level of its superimposition on the basisphenoid bone and caudal to the sigmoid flexure. The occlusion of this site first is to protect the cerebral circulation from accidental air or thrombus embolization (Hardy *et al.* 2003). To embolize the distal ICA, coils with 5 to 8 mm diameter are usually necessary (Freeman *et al.* 2012). A Dacron fiber-cover, stainless steel, occluding spring embolization coil of the proper diameter is introduced through the catheter and placed within the ICA using a guidewire. A coil slightly larger than the artery is placed first, and additional smaller imbricating embolization coils are introduced until complete occlusion is obtained (Hardy *et al.* 2003). After placing the coils, the occlusion is verified by injection of contrast material. Then, the proximal side of the ICA is embolized, midway between the first embolization site and its origin from the CCA (Freeman *et al.* 2012). The catheter is withdrawn into the CCA, and advanced to repeat the same procedure in the caudal MA and rostral ECA. The MA is embolized distal to the superficial temporal and proximal to the infraorbital, buccal, and mandibular alveolar arteries (Hardy *et al.* 2003). Correct identification of the MA is verified by insertion of the catheter in the ophthalmic artery, then the catheter is withdrawn until it is within the alar foramen, just distal to the curvature of MA, and cranial to the most cranial aspect of the guttural pouch outline. Coils of 8 to 12 mm are used at this place (Freeman *et al.* 2012). The ECA is the embolized caudal to the origin of the caudal artery. The ECA requires the

largest size and number of coils to achieve immediate and complete occlusion. Coils with 10 to 15 mm diameter are usually used in the ECA (Freeman *et al.* 2012). After coil placement, the catheter and introducer system are removed. The CCA puncture site is closed using 5-0 silk in a cruciate pattern, and the muscle layers and skin are closed in three layers. After the surgery, the horses are rested for 30 days and then return gradually to normal activity (Freeman *et al.* 2012). This technique has some disadvantages, such as, the requirement of fluoroscopy, specialized equipment and expertise. The transarterial coil embolization of the ICA was performed successfully in standing horses, avoiding general anesthesia and recovery complications, decreasing total time of intervention and the cost of the procedure approximately in one-third (Benredouane *et al.* 2012).

The transarterial nitinol vascular occlusion plug embolization, was described in three horses. One difference between the use of nitinol vascular plugs and transarterial coils is that a single nitinol plug is delivered at each site to stop blood flow. Instead at least two transarterial coils are used at each site to effectively stop blood flow. If unsatisfactory placement is noted of the nitinol plug, it is possible to retract the nitinol plug into the delivery cable. The plug can also be retrieved after it has been released, and because of the radial tension that they exert on the vessel wall, the nitinol vascular plugs turn out to be less susceptible to become dislodged if they have a proper size (Hawkins *et al.* 2011).

G. PROGNOSIS

Tympany

The prognosis for complete recovery is usually favorable after fenestration of the median septum by any method (Freeman *et al.* 2012). Secondary empyema and pneumonia usually resolve spontaneously after successful treatment of the tympany, but for foals that have aspiration pneumonia and dysphagia by nerve damage during the surgery the prognosis is guarded (Freeman *et al*. 2012). Although it can be sometimes difficult, for a successful treatment it is important to make a correct diagnosis, distinguishing between unilateral or bilateral involvement. In one retrospective study using a surgical laser technique on 50 horses (described in one of the clinical cases here presented), 35 of the 50 horses required only one surgical treatment and all 50 were

cured successfully after two surgical treatments (Blazyczek *et al.* 2004), giving this disease a good prognosis when the affected animals receive a proper therapy.

Empyema

The response to the adequate treatment is usually good, the neurological signs can resolve after a successful treatment of the infection (Freeman *et al.* 2012)

Guttural pouch mycosis

The prognosis in cases of guttural pouch mycosis is dependent on the degree of cranial nerve involvement, it is generally good after arterial occlusion, in cases in which the horse does not present neurological clinical signs (Rush *et al.* 2004). When the neurological clinical signs are present prior to the surgery (particularly dysphagia) the prognosis can be poor. Horses with laryngeal hemiplegia or Horner's syndrome, prior to the treatment, can take up to 18 months for full recovery (Pollock 2007). In one study using the transarterial coil embolization in 31 horses with guttural pouch mycosis, the survival rate using this technique was 84% and 71% returned to the level of competition expected by the owner or trainer (Lepage *et al.* 2005), making this the preferred treatment.

III. CLINICAL CASES

A. CLINICAL CASE 1

Patient profile: "horse number 1" –1-month-old, 70-kg, Arabian filly

History: "horse number 1" was admitted to the equine clinic of the University of Veterinary Medicine Hanover, because of severe, bilateral distention in the region of Viborg's triangle. The swellings were soft, compressible, elastic, palpation of the swellings did not cause the horse to show signs of pain. The left side was more distended than the right side. The filly made a snoring noise during inspiration, and during pulmonary auscultation, inspiratory sounds were bilaterally exacerbated.

Physical examination (at admission): the filly was bright, alert, and responsive. Its heart rate was 72 bpm, regular and rhythmic, and its respiratory rate was 32 bpm. Its mucous membrane were pink and moist, and the capillary refill time was < 2 seconds. Gastrointestinal sounds were normal and the digital pulse could not be felt. The filly had an abnormal, bilateral serous nasal discharge, and its mandibular lymph nodes were slightly enlarged (hazelnut size). The filly's body condition was of average.

Complementary examinations: Results of a CBC and serum biochemical analyses were within the normal range. During endoscopic examination of the upper portion of the filly's respiratory tract, we observed the dorsoventral narrowing of the nasopharynx, especially on the left side of the nasopharynx. The soft palate occasionally became displaced dorsally, obstructing the larynx. The pharyngeal openings of the guttural pouches appeared normal anatomically, but white fluid filled the ventral aspect of the left guttural pouch while endoscopically examining the right guttural pouch, we observed that the septum separating the guttural pouches bulged into the right guttural pouch.

Final Diagnosis: guttural pouch tympany

Treatment: The median septum of the guttural pouch was fenestrated with a laser (Nd:YAG laser) transendoscopically, and the medial lamina was partially resected. The filly was administered flunixin meglumine and trimetoprim-sulfadiazine before surgery. Anesthesia was induced with detomidine, midazolam, and ketamine. The filly was positioned in lateral recumbency, and supported on the head and limbs by assistants.

The endoscope passed into the lesser affected guttural pouch, in this case the right one, to fenestrate the median septum in a caudal to rostral direction. The medial lamina was partially excised with the laser by inserting the endoscope through the most affected guttural pouch, the left one.

Therapeutic protocol: Flunixin-meglumine (Flunidol™), 1.1 mg/kg, orally, q12h, the first day and q24h thereafter, for 4 days; trimetoprim-sulfadiazine (Synutrim™) 30 mg/kg, orally,q12h for 5 days; omeprazole (Gastrogard™), 3 mg/kg, orally, q24h, for 6 days, begining the second day after surgery

Prognosis: Good

Evolution of the case: Distension of the right side was no longer recognizable after surgery, but the left side remained slightly distended. The filly had seromucous nasal discharge at the left nostril and still made an inspiratory snoring noise. The inspiratory snoring noise disappeared after 4 days, and the seromucous nasal discharge disappeared by 5 days after surgery. The filly was discharged 9 days after surgery, and at this time, the swelling in the parotid region had disappeared, although the left parotid region remained thicker than the right parotid region. The owner reported, 2 month after the surgery, that the filly had no signs of guttural pouch tympany and that its respiration was normal.

B. DISCUSSION OF THE CLINICAL CASE 1

The filly was presented with bilateral swellings in the parotid regions, with left swelling more prominent than the right, but knowing for certain whether guttural pouch tympany was confined to just the left side could not be known for certain, and consequently two procedures were performed. When the guttural pouch tympany is unilateral, it is possible effectively to treat the affected horse by fenestrating the septum, thereby allowing release of air from the tympanic guttural pouch through the opening of the unaffected guttural pouch, or by partially resecting the medial lamina to allow release of air through the guttural pouch opening. When the guttural pouch tympany is bilateral, both procedures (i.e., fenestration of the medial septum and partial resection of the medial lamina) must be performed. In this case, performing both procedures resulted in complete resolution of tympany. Both procedures were performed because we were unable to determine with certainty that only the left guttural pouch was tympanic. The 2 open surgical approaches that are used for treat horses for this disease are more invasive

than was this minimally invasive surgery using laser. Both procedures used in this case, can be performed with a low risk of damage of the important structures within the guttural pouch (as nerves and vessels), and both procedures can be performed successfully with the horse sedated. More conservative treatment by inserting an indwelling catheter into the affected guttural pouch to deform to the plica salphingopharyngea is another option to treat horses for guttural pouch tympany, but this approach is unlikely to succeed in the long-term and could create complications, such as guttural pouch empyema, broncopneumonia, and permanent deformity and scarring in the cartilage of the pharyngeal ostium.

C. CLINICAL CASE 2

Patient Profile: "horse number 2"– a 5-year-old, German warmblood mare

History: The mare was admitted in 25th of January, 2014 to the equine clinic of the University Veterinary Medicine of Hanover, because of mucopurulent, left nasal discharge and serosanguineous, right nasal discharge. The horse had suffered an episode of epistaxis and was nervous and agitated in the stall.

Physical examination: The mare was excited/nervous. Its heart rate was 44 bpm, strong, regular, and rhythmic, Its respiratory rate was 16 bpm, and its temperature was 37.8°C. Its mucous membranes were pale, and its capillary refill time < 2 seconds. Gastrointestinal sounds were present in all quadrants. The digital pulse could not be felt. It has a mucopurulent discharge at the left nostril and a serosanguineous discharge at the right nostril. The mandibular lymph nodes were slightly enlarged (hazelnut size), lobulated, firm, elastic, and movable. Palpation of the lymph nodes did not cause the horse to show signs of discomfort. The mare had no cough reflex. The mare was of average body condition and weighed 570 kg.

Complementary examinations: Blood work: The mare was anemic (hemoglobin-82g/l; (reference range 110-170 g/l); hematocrit-23.3%, (reference range 30-45%)). During endoscopic examination of the upper portion of the horse's respiratory tract, we observed mucopurulent exudate draining from the nasopharyngeal opening of the left guttural pouch and blood and mucus draining from the nasopharyngeal opening of the right guttural pouch. We observed several fungal plaques on the medial and lateral compartment of the right guttural pouch; those in the medial compartment were located in the dorsal aspect and overlying the rectus capitus longus muscle and the medial

septum, and those in the lateral compartment were located in the dorsal aspect overlying the maxillary artery and digastricus muscle. During endoscopic examination of the left guttural pouch, we observed fungal plaques in the medial compartment, overlying the rectus capitus longus muscle and on the medial septum. We observed purulent fluid on the floor of the medial compartment. Based on clinical and endoscopic examinations, we concluded that the cause of abnormal nasal discharge was bilateral guttural pouch mycosis.

Final Diagnosis: Mycosis of the guttural pouch

Treatment: the transarterial coil embolization technique was the treatment chosen. Anesthesia was induced with ketamine and midazolam and maintained with isoflurane. The mare was placed in left lateral recumbency, and the head and neck were placed on radiolucent surface. The proximal aspect of the jugular groove was clipped, prepared for aseptic catheterization, and draped. This technique was performed using fluoroscopic guidance. An approximately 8-cm longitudinal skin incision was made at the junction of the proximal and middle third of the neck just dorsal to the jugular vein. The brachiocephalicus and omohyoid muscles were bluntly separated, and the carotid sheath was elevated by blunt finger dissection. The common carotid artery was separated from the vagosympathetic trunk, elevated with two Penrose drains, and punctured with an angiographic needle. A 6-French introducer system was inserted in the artery and guided toward the head. A 6-French, single end-hole, nylon angiographic catheter was inserted rostrally into the common carotid artery to the level of the internal carotid artery using fluoroscopic guidance. An angiogram was performed by hand injection of a solution of iohexol in heparinized physiological saline solution (1:2 ratio) to identify the branches of the common carotid artery and to estimate the diameter of each branch. To embolize the ICA. 1, 5-mm diameter coil and 3, 8-mm diameter coils were placed into the ICA, two caudal to the sigmoid flexure and two in the origin of the ICA, 5-mm coil was placed first. The embolization coils were introduced through the catheter, and pushed into the ICA by the stiff end of a guide wire, and after each was inserted, occlusion was verified by injecting radiocontrast material. After the embolization of the ICA, the catheter was withdrawn into the CCA and advanced to repeat the same procedure in the caudal Maxilar artery and rostral aspect of the External Carotid artery. The MA was next embolized using 3, 8-mm diameter coils, distal to the superficial

temporal artery and proximal to the infraorbital, buccal, and mandibular alveolar arteries. The ECA was embolized using 2, 10-mm diameter coils. The coils were inserted caudal to the origin of the caudal auricular artery. After the coil placement, the angiographic catheter and the introducer system were removed. The CCA puncture site was closed with an interrupted suture of PDS 3-0, the musculature and skin were closed separately using polyglactin 910 placed in a simple continuous pattern.

Therapeutic protocol: flunixin meglumine (Flunidol™), 1.1 mg/kg orally, q12h for 2 days and q24h for two days; trimethoprim-sulfadiazine (Synutrim™) orally, 30mg/kg q12h for 5 days; cefquinome (Cobactam™) 1mg/kg, i.m, q24h for 10 days; metamizole (Novacen™), 40 mg/kg , intravenously (when the temperature was above 39.5ºC)

Prognosis: guarded

Evolution of the case: the surgery occurred without complication. After surgery, the mucous membranes remained pale, and the mandibular lymph nodes remained slightly enlarged (hazelnut size). Flunixin-meglumine was administered for 4 days to minimize inflammation at the incision, and trimethoprim-sulfadiazine was administered for 5 days. The horse had no more episodes of epistaxis after surgery, and in the 4th day after day surgery, the hematocrit was 25.8% (30-45%) and the hemoglobin 91 g/l (110-170 g/l). On day 5 after the surgery, the horse was dull and inappetent and had episodes of the fever, and mucopurulent discharge containing food flowed from the nostrils. It was administered metamizole i.v. to control fever episodes when the temperature rose above 39.5ºC and to relieve pain. Six days after surgery, the horse antimicrobial therapy was changed trimethoprim-sulfadiazine to cefquinome, which the horse received for 10 days. The horse's attitude and appetite improved after each administration of dipyrone, and by 8 days after surgery, the horse was alert, its temperature was within normal range, and its mucous membrane were pink. At 10 days after surgery, however, the horse was dull and displayed neurological abnormalities, such as ataxia and headshaking. Cranial nerve function and neck mobility were normal, but ptosis of both eyes was observed. On day 11 after surgery, ptosis was no longer observed. When the guttural pouches were examined endoscopically at 12 days after surgery, the fungal plaques in the left guttural pouch were smaller and although those in the right guttural pouch were the same size, their margins were observed to be more regular. Pulsation of

the right ECA was noted. During radiographic examination performed to determine the position of the embolization coils, we observed that the coils in ECA had displaced cranially. At day 15 after surgery the horse developed mucoid nasal discharge but was no longer ataxic. The suture incision was dry and clean. During endoscopic examination performed 19 days after surgery, the fungal plaques in the both guttural pouches were smaller and smoother, but pulsation of the right ECA was still noted. During endoscopic examination performed 36 days after surgery, we observed that the fungal plaques in the in the left guttural pouch were smaller, but those in the right guttural pouch had enlarged. Fungal plaques were removed from both guttural pouches using an endoscopic grasping forceps, and the pouches were lavaged with a dilute solution of tamed iodine. The guttural pouches were examined endoscopically (on day 38, 40, and 45 after surgery), to remove fungal plaques, and on these days, the pouches were lavaged a dilute solution of iodine. During examination on day 45, we observed that the fungal plaques in both guttural pouches were smooth and decreased in size. The horse was allowed to gallop for 10 minutes and to trot for 20 minutes daily. On day 52, the fungal plaques were smaller but covered with slimy deposits, and at this time, the horse suffered from dysphagia, and food particles were observed in the pharynx and trachea. By day 59 the horse no longer suffered from dysphagia, and the slimy deposits noted during the previous endoscopic examination had decreased in size. On days 73, 80, and 87 in these endoscopies, the necrotic tissue and the slimy deposits were observed to be decreasing in size, and the fungal plaques were smaller than the previous endoscopies, in the last endoscopy the horse was almost free of fungal plaques. The horse had no signs of guttural pouch mycosis and was in good body condition when it was discharged 88 days after surgery.

D. DISCUSSION OF THE CLINICAL CASE 2

The mare was presented because of epistaxis, abnormal nasal discharge, presumed to be caused by guttural pouch mycosis. The diagnosis of guttural pouch mycosis was confirmed during endoscopic examination of the guttural pouches. Fungal plaques observed in the right guttural pouch had penetrated the median septum into the left guttural pouch. The fungal plaques had not covered the arteries of the left guttural pouch. Guttural pouch mycosis is a life-threatening disease of the horse due risk a fatal epistaxis that is usually caused by fungal erosion of the wall of the ICA (2/3 of cases) or the ECA or MA (1/3 of cases) of the ECA or MA. To prevent hemorrhage from the

affected arteries, controlled thrombosis of the blood vessels of the right guttural pouch using an embolization coils was performed. The procedure was performed on the right side of the horse, only the arteries from the right guttural pouch were involved. The transarterial coil embolization technique is considered the gold standard treatment for horses with guttural pouch mycosis. This treatment requires no daily lavage of the guttural pouch with povidone-iodine or systemic administration of an antifungal drug. The results of non-surgical treatment of horses for guttural pouch mycosis are not satisfactory because non-surgical treatment is prolonged treatment and doesn't always prevent the horse from suffering fatal hemorrhage. Ligation of the ICA at it is origin, is not considered an effective treatment, because blood flow in the circle of Willis maintains arterial blood pressure in the affected segment of the artery, which can lead to retrograde fatal hemorrhage. Ligation of the ECA distal to the origin of the linguofacial trunk, is not a successful treatment because the MA and ECA have numerous collateral channels that allow retrograde flow to the affected segment. The balloon-tipped catheter arterial occlusion is a technique in which a catheter is passed into the affected artery at distant site, and passed beyond the lesion, where the balloon is inflated, occluding the blood flow. A ligature is placed on the cardiac side of the vessel, which can be accessed at the level of the carotid trifurcation. When using this technique, the surgeon must to know which vessel is affected. The balloon catheter is removed 14 days after surgery. Complication associated with this procedure could be breakage of the catheter during removal, retrograde infection, wound infection, recurrent epistaxis, and inappropriate catheter placement. The last two complications occur when an aberrant branch from the affected vessel is occluded leaving the affected segment of artery open for retrograde blood flow. Before the surgery, this mare had no neurological signs of dysphagia or laryngeal hemiplegia indicating that the mare's prognosis for recovery was good. After the surgery the horse developed neurological signs, such as ataxia, headshaking, ptosis, and dysphagia. The headshaking was not known, but dysphagia was thought to be related to damage or inflammation of the glossopharyngeal nerve and the pharyngeal branch of the vagus nerve. The ptosis was thought to be related to disturbances in the cranial cervical ganglion. The horse received no treatment for these clinical signs, which eventually solved. Reasons for these neurological signs could have been neuritis caused by the fungal plaques. Another complication that can develop from surgery include Horner's syndrome caused by damage of the sympathetic trunk and recurrent laryngeal neuropathy caused by damage to the recurrent laryngeal nerve. The

anemia noted before surgery soon resolved after surgery. The pale mucous membranes were associated with anemic state of the patient. To control the episodes of fever that occurred 5 days after surgery and to relieve pain, the horse was administered metamizole when the temperature was above 39.5ºC. Antimicrobial therapy using trimethoprim-sulfadiazine was discontinued, and antimicrobial therapy using cefquinome was instituted, because the horse developed fever episodes, the antimicrobial therapy was changed for one antibiotic the larger spectrum, as a cefquinome. During one of the endoscopic examinations we observed pulsation in ECA, indicating that the artery was not completely thromobosed. During radiographic examination, we observed that embolization coils in the ECA had become displaced, probably because the 10-mm diameter coils placed into the ECA were too small. For complete occlusion of the ECA and to avoid this displacement, coils should be between 10 and 15 mm in diameter.

IV. CONCLUSION

Guttural pouch diseases are not common but they can be life-threatening because the guttural pouches are anatomically associated with several important neural and vascular structures. In the last years some minimally invasive techniques were developed allowing to perform a successful treatment without iatrogenic damage of these important structures. In all guttural pouch diseases it is very important to make an early diagnosis and prompt intervention, to prevent secondary problems associated with the diseases affecting the guttural pouch. The main problems of these minimally invasive techniques are the requirement of special equipment such as fluoroscopy or transendoscopic laser surgery and their cost, that limit their use to a small number of clinics.

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VI. APPENDICES

A. APPENDICES CLINICAL CASE 1

Figure 8: Horse nº1 with gultural pouch tympany, sever distension in the left region of Viborg's triangle, the more distended side.

Figure 9: Horse nº1 with bilateral swelling in the region of Viborg´s triangle.

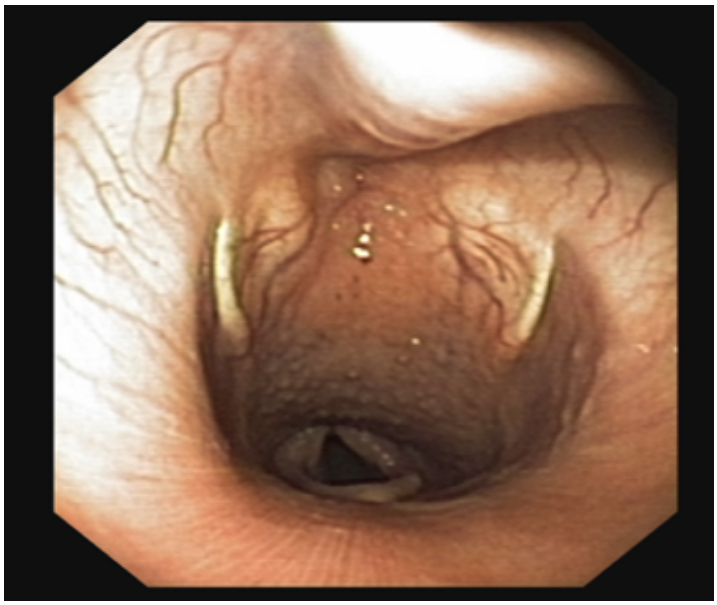

Figure 10: Endoscopy of the horse number 1, showing collapse of the dorsal pharyngeal wall.

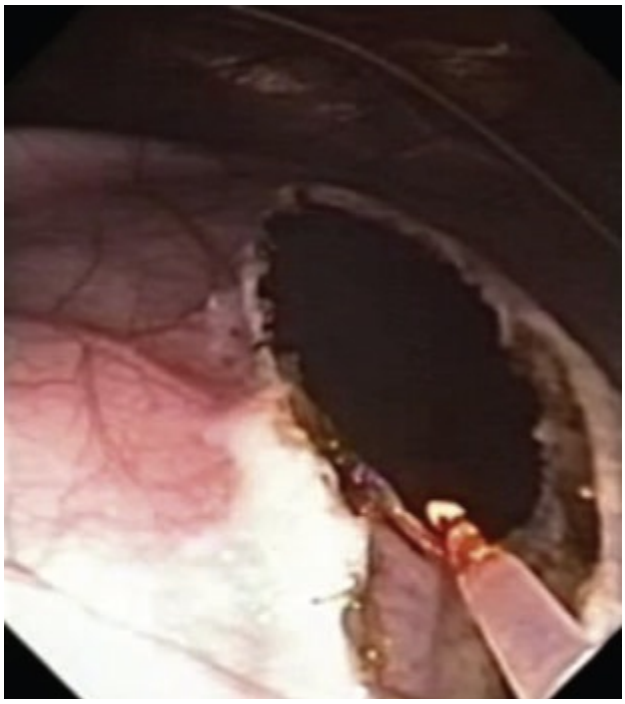

Figure 11: Fenestration of the median septum with a laser (Nd:YAG laser) transendoscopically, endoscope turned 90º (Adapted from Ohnesorge *et al.* 2012).

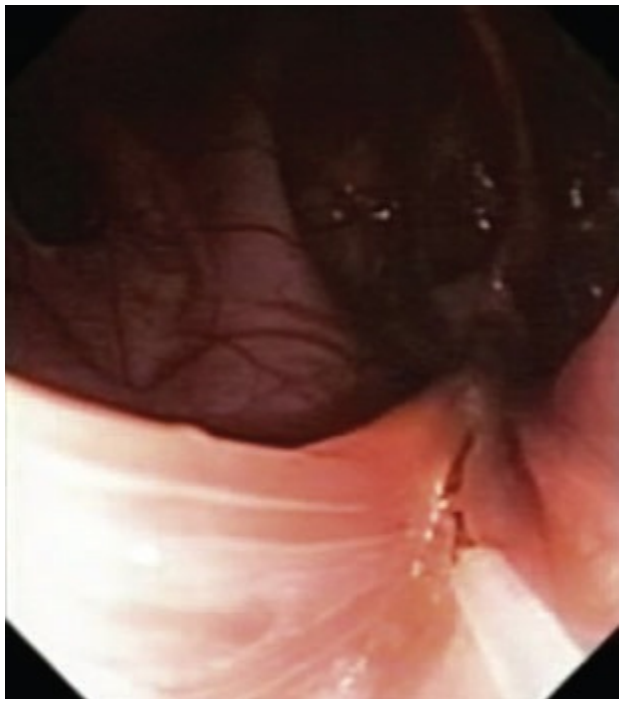

Figure 12: Partial resection of the medial lamina, endoscope turned 180º (Adapted from Ohnesorge *et al.* 2012).

Figure 13: 9 days after the surgery, the horse number 1 was discharged and had no signs of guttural pouch tympany.

B. APENDICES CLINICAL CASE 2

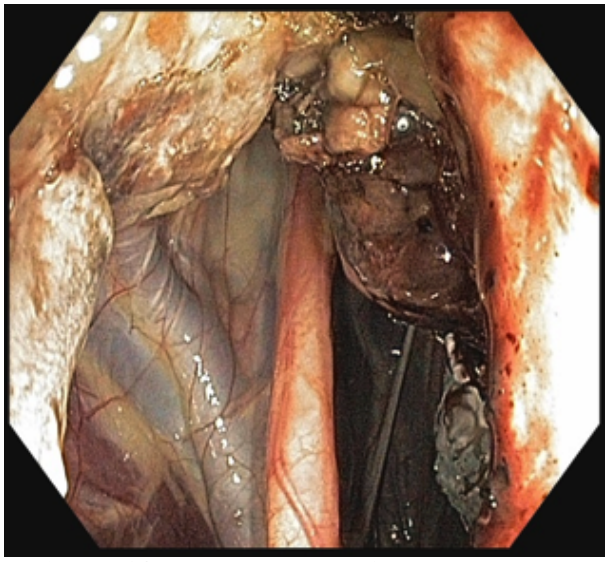

Figure 14: horse number 2, guttural pouch mycosis on the roof of the medial compartment and the lateral wall of the lateral compartment of the right guttural pouch, in the surgery day.

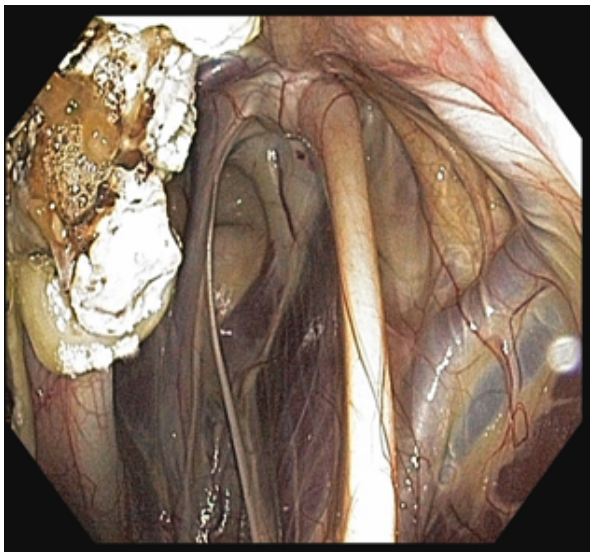

Figure 15: horse number 2, guttural pouch mycosis on the medial wall of the medial compartment of the left guttural pouch, in the surgery day.

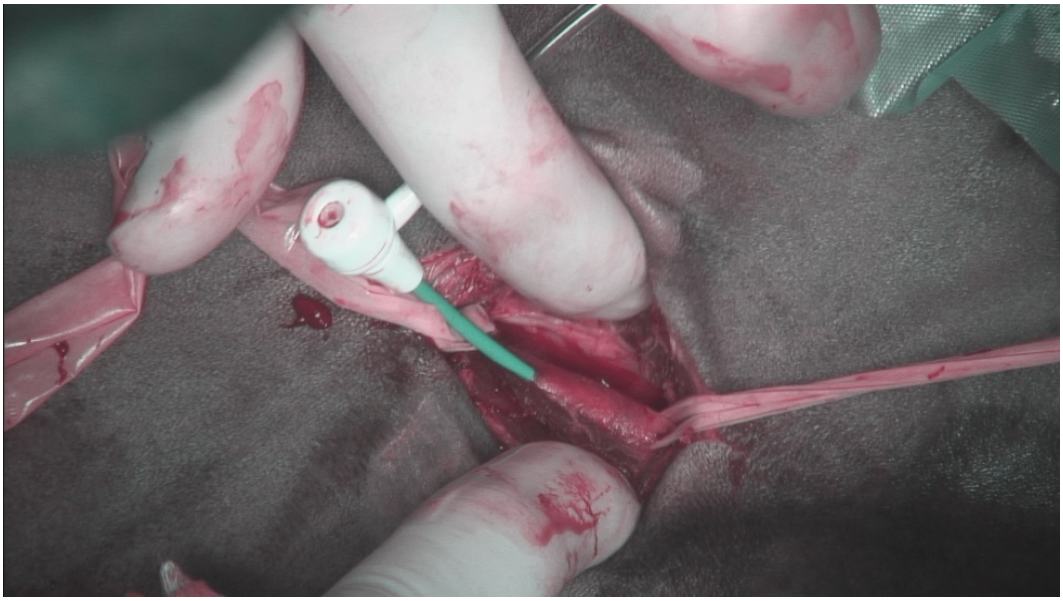

Figure 16: horse number 2 - the common carotid artery was elevated with two Penrose drains and 6-French introducer system is inserted into the artery

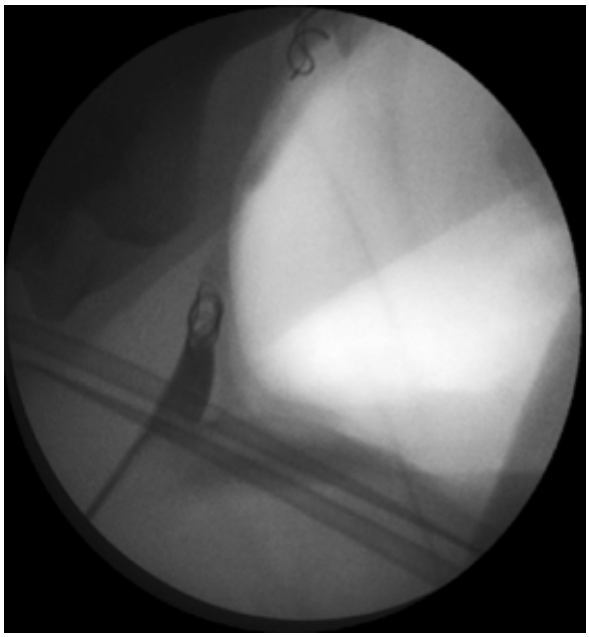

Figure 17: Fluoroscopic image showing correct placement of the coils in the ICA of the horse number 2. The contrast material with complete occlusion of the artery and the angiographic catheter within the ICA.

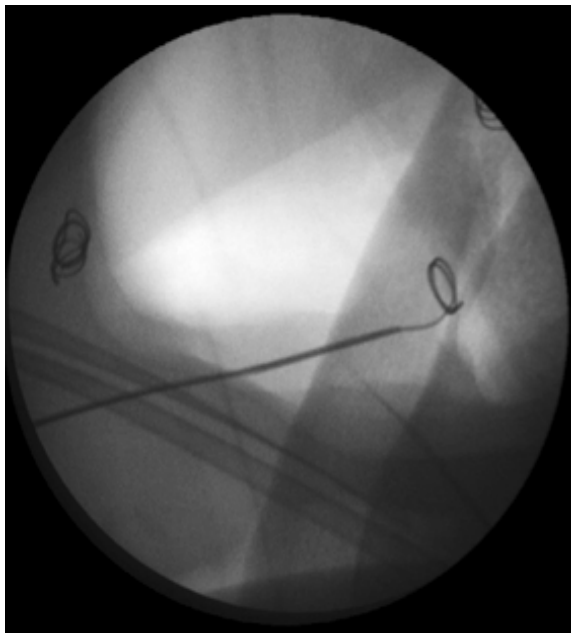

Figure 18: Placement of the 10-mm diameter coil in the ECA of the horse number 2, through the angiographic catheter.

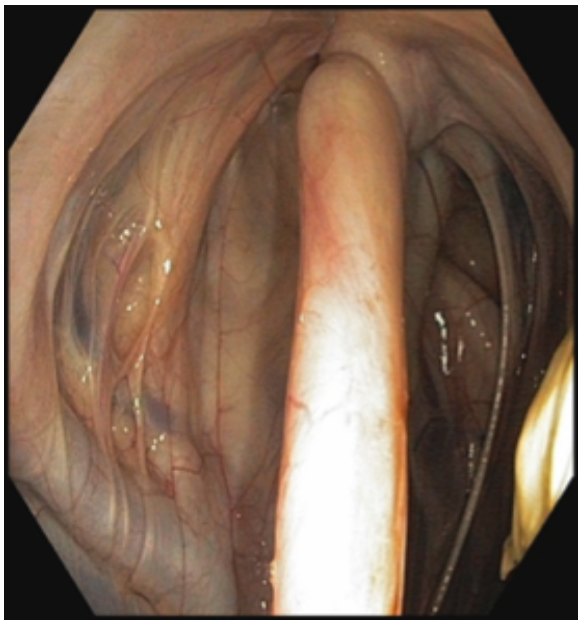

Figure 19: horse number 2, 87 days after the coil embolization, the endoscopy showing necrotic tissue (white material) on the medial aspect of the medial compartment of the right guttural pouch.

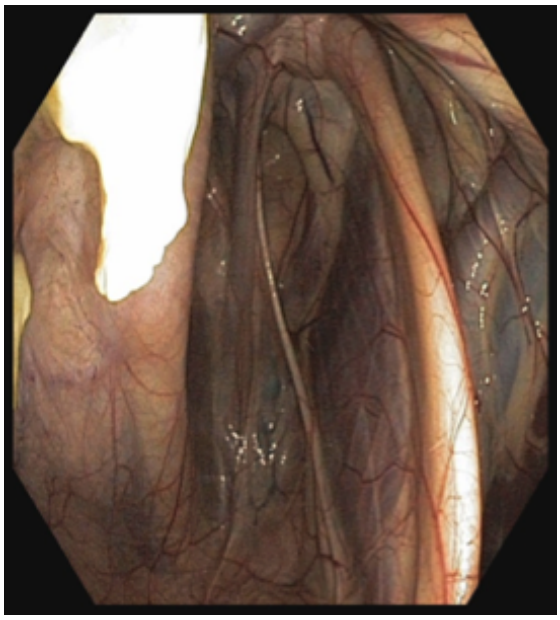

Figure 20: horse number 2, endoscopy of the left guttural pouch showing necrotic tissue on the medial wall of the medial compartment, 87 days after the coil embolization.