UNIVERSIDADE DE LISBOA

FACULDADE DE MEDICINA VETERINÁRIA

COMPLICATIONS AND SURGICAL OUTCOME IN DOGS WITH OTITIS MEDIA UNDERGOING TOTAL EAR CANAL ABLATION AND LATERAL BULLA OSTEOTOMY: A RETROSPECTIVE STUDY OF 37 CASES

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Complications and surgical outcome in dogs with otitis media undergoing total ear canal ablation and lateral bulla osteotomy: a retrospective study of 37 cases

Abstract

Nowadays total ear canal ablation combined with lateral bulla osteotomy (TECA-LBO) is the gold standard surgical technique for the treatment of dogs diagnosed with chronic otitis externa or otitis media nonresponsive to medical treatment. Regardless, of its efficiency in the resolution of otitis, several types of complications may occur.

This study aimed to retrospectively revise postoperative complications and surgical outcome in a group of dogs submitted to this procedure in 2 referral institutions.

Bacterial infection was found in 86.49% of the cases and postoperative complications were present in 54.05% of the cases. Neurological complications occurred in 35.14% of the cases, abscess or fistulation occurred in 18.92% of the cases, and suture dehiscence in 21.62% of the cases.

No associations were found between the occurrence of complications and the dog's age, sex, breed or presence of bacterial infection. There was also no association between the surgical outcome and the animal's age, sex, breed or presence of bacterial infection.

It was found an association between the postoperative complications and a poor surgical outcome, in particular with the presence of abscess or fistulation. On the contrary it was found an association between the suture dehiscence and a better surgical outcome. No association was found between the occurrence of neurological complications and the surgical outcome.

In the great majority of the cases the outcome was good, corroborating the fact that TECA-LBO is an effective surgical technique in the resolution of otitis media.

Key-words: Total ear canal ablation, Lateral bulla osteotomy, Otitis media, Dog, Complications, Outcome

Complicações e resultado cirúrgico em cães com otite média submetidos a ablação total do conduto auditivo e osteotomia lateral da bula timpânica: estudo retrospetivo de 37 casos

Resumo

Atualmente, a ablação total do conduto auditivo associada à osteotomia lateral da bula timpânica (TECA-LBO) é a técnica cirúrgica recomendada para o tratamento de cães com diagnóstico de otite externa crónica ou otite média não responsiva ao tratamento médico. Apesar de ser uma técnica extremamente eficaz na resolução de otites, vários tipos de complicações podem ocorrer.

O objetivo deste estudo foi rever retrospetivamente as complicações pós-operatórias e os resultados cirúrgicos de um grupo de cães submetidos a este procedimento em 2 instituições de referência.

A presença de infeção bacteriana foi encontrada em 86.49% dos casos e as complicações pós-operatórias em 54.05% dos casos. Complicações neurológicas ocorreram em 35.14% dos casos, abscesso ou fístula em 18.92% dos casos e deiscência de sutura em 21.62% dos casos.

Não foram encontradas associações entre a ocorrência de complicações e a idade, sexo, raça ou presença de infeção bacteriana. Também não houve associação entre o resultado cirúrgico e a idade, sexo, raça ou presença de infeção bacteriana.

Foi encontrada associação entre as complicações pós-operatórias e um mau resultado cirúrgico, principalmente na presença de abscesso ou fístula. Pelo contrário, foi encontrada associação entre a deiscência de sutura e um melhor resultado cirúrgico. Não foi encontrada associação entre a ocorrência de complicações neurológicas e o resultado cirúrgico.

Na grande maioria dos casos o resultado foi bom, corroborando o fato da TECA-LBO ser uma técnica cirúrgica eficaz na resolução da otite média.

Palavras-chave: Ablação total do conduto auditivo, Osteotomia lateral da bula timpânica, Otite média, Cão, Complicações

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List of Abbreviations

CRI - Constant Rate Infusion
CT - Computed Tomography
FLK - Fentanyl, Lidocaine, Ketamine
LBO - Lateral Bulla Osteotomy
MLK - Morphine, Lidocaine, Ketamine
MRI - Magnetic Resonance Imaging
TECA - Total Ear Canal Ablation
% - Percentage
® - Trademark

Chapter I - Internship Report

1. Internship at the University of Budapest

As part of the integrated master's degree in veterinary medicine I decided to do my curricular internship at the Small Animal Clinic of the University of Budapest. However due to the pandemic situation the internship had to be cancelled, and I only stayed at the hospital during 6 weeks (instead of the planned 4 months), between 3rd February and 12th March of 2020. The internship was then continued at the University of Lisbon. During this period I participated in the surgery service routine which consisted in discuss clinical cases and their respective radiographies or CT scans, assist pre-surgical appointments, help in the preoperative care (take blood samples, premedication, catheterization, intubation, trichotomy, and sterile preparation of the skin), anesthesia monitoring, scrub in for surgeries, and help in the postoperative care. During the internship I could observe and participate in several soft tissues surgeries (including TECA-LBO in dogs), orthopaedic surgeries and dentistry treatments. It was possible to learn about a great variety of surgeries such as correction of patent ductus arteriosus, urethrostomy, portosystemic-shunt correction, correction of chylothorax (thoracic duct ligation and pericardiectomy), ovariectomy and orchiectomy, excision of tumours and masses, cystotomy, mandibulectomy, foreign body removal, adrenalectomy, exploratory laparotomy, splenectomy, anal sacculectomy, perineal herniorrhaphy, nephrectomy, correction of laryngeal paralysis (lateralization of the arytenoid cartilage), correction of tracheal collapse, cholecystectomy due to gallbladder mucocoele, as well as dentistry treatments (exodontia, scaling and polish of teeth) and orthopaedic procedures. I also had the opportunity to develop and improve some surgical skills, mostly intradermic and skin sutures.

2. Internship at the University of Lisbon

The internship was complemented with 5 weeks at the Veterinary School Hospital of the University of Lisbon between 8th June and 10th July of 2020. During this period I participated in rotations of different services. I spent 2 weeks in the surgery service, 2 weeks in general medicine and 1 week in diagnostic imaging. In the surgery service I could help in the preoperative care (take blood samples, premedication, catheterization, intubation, trichotomy, and sterile preparation of the skin), anaesthesia monitoring, scrub in for some surgeries, and help in the postoperative care. I had the chance to participate and observe some soft tissues surgeries (mostly spays, cystotomies, tumour resections, splenectomies, mandibulectomies, among others), a few orthopaedic surgeries and advanced dentistry treatments. I also had the opportunity to improve some surgical skills. In the general medicine service, I had the chance to observe and participate in consultations, preform physical examinations, take blood samples for analysis and discuss the appropriate diagnosis tests, discuss the best treatment for each case, give medication, vaccination and have contact with the animals' tutors. In the echography service I had the chance to observe the ultrasound examinations, take blood samples, preform cystocentesis, and also discuss clinical cases having into account the alterations observed.

3. Internship at the University of Turin

Initially, the internship at the Small Animal Hospital of the University of Turin was considerate as an extracurricular internship, however the hours spent there were added to the curricular internship in order to complete it. I stayed a total of 11 weeks at the hospital, doing clinical rotations in 9 different services, between 1st October and 13th December of 2019. In the internal medicine service, I could assist appointments, preform physical examinations and discuss clinical cases. In the oncology service it was possible to collect samples for cytology and discuss the best treatment options. In soft tissue surgery I could observe and participate in several surgeries (including oncological, head and neck, thoracic, and abdominal surgery). In the orthopaedics service I was able to assist some appointments and observe or participate in a few surgeries as well. In the neurology service I could observe and help in the neurological examinations as well as discuss clinical cases. In the emergency service and internment room I could perform physical examinations, give medication and help in the recovery of the animals hospitalized. In the diagnostic imaging rotation I could assist the ultrasound examinations that included abdominal ultrasound and echocardiography, as well as discuss the alterations observed. In the cytology laboratory I had the chance to analyse cytology slides and discuss the respective diagnosis. During the ophthalmology rotation I could observe and help in the ophthalmological examinations, and also had the opportunity to discuss the best diagnosis tests and treatment for each case. In the anaesthesiology service the activities consisted of helping in the preoperative care (blood samples collection, premedication, catheterization, intubation, trichotomy, and sterile preparation of the skin), anaesthesia monitoring, and postoperative care.

Chapter II - Literature Review

1. Anatomy of the dog's ear

The ear is a sense organ and it has a double function. It is not only an auditory organ for the perception of sound but also an organ of equilibrium giving the animal the awareness of his body position (König and Budras 2007). Hearing requires at least one ear, to localize sounds both ears are necessary (Uemura 2015). The ear can be divided in three anatomical and functional regions: the external ear, middle ear, and inner ear (Figure 1) (Cochran 2011).

2. The External Ear

The external ear consists of the pinna or auricle and the external acoustic meatus or external ear canal (Evans and Lahunta 2010). It varies significantly when it comes to size and shape according to the species (Evans and Lahunta 2013) and due to selective breeding, particularly in dogs, the external ear has a wide diversity of appearances (Harvey et al. 2001).

The pinna or auricle is the only part of the ear externally visible (Evans and Lahunta 2013). It is a mobile and flexible structure conceived to localize and collect sound waves (Akers and Denbow 2013) directing them into the external ear canal (Uemura 2015). In most animals the pinna is formed by a funnel-shaped cartilage (Reece 2005), where the size and shape of the nontubular auricular cartilage defines the posture of the pinna, which may be upright (erect) or pendulous (folded) (Evans and Lahunta 2013).

The external ear canal or external acoustic meatus consists of an initial vertical canal that runs ventrally and slightly rostral before bending to a shorter horizontal canal (Kumar and Roman-Auerhahn 2005). The horizontal canal is supported by the temporal bone (Singh 2018), being also the part where the ear canal ends at a delicate tissue, the tympanic membrane (Aspinall and Cappello 2015). The vertical canal and the initial part of the horizontal canal are cartilaginous, however its deepest part is osseous (Kumar and Roman-Auerhahn 2005). The lumen of the ear canal is irregular (Monteiro-Riviere 2006), contains hair follicles and specialized sebaceous and ceruminous glands (Akers and Denbow 2013) which the secretions form earwax or cerumen. This earwax protects the canal and keeps the tympanic membrane wet and flexible (Kumar and Roman-Auerhahn 2005).

3. The Middle Ear

The middle ear consists of the space within the osseous tympanic bulla, the opening of the auditory tube, and the three ear ossicles (Kumar and Roman-Auerhahn 2005). The middle ear is a cavity filled with air, housed in the temporal bone and connected with the nasopharynx through the eustachian tube (Klein 2013), which allows the pressure on the tympanic membrane to be the same on its internal and external surface (Cochran 2011).

The tympanic membrane or eardrum covers the entrance to the tympanic cavity being the structure between the external ear canal and the middle ear cavity (Evans and Lahunta 2013). The external surface is cutaneous and it has no hair, glands or pigment. The central surface is a vascular connective tissue, attached to the ossicle anulus. The inner surface is a mucous membrane (König and Budras 2007) that extends onto the ossicle malleus, and it is attached to it by the *umbo* of the tympanic membrane (König and Liebich 2004). The tympanum is a delicate, semi-transparent membrane, oval in shape (Tobias 2013a) and concave externally (Bellah 2013). It can be divided into two portions: a superior part, the *pars flaccida* and an inferior part, the *pars tensa* (Bellah 2013). The *pars flaccida* is a small and triangular portion positioned between the ossicle malleus and the tympanic incisure (Evans and Lahunta 2013). It has blood vessels offering a pink colour to this region (Evans 1993; Harvey et al. 2001; Heine 2004; Kumar 2005; Cole 2009). The *pars tensa* is attached to the fibrocartilaginous annulus ossicle (Evans and Lahunta 2013), being a thin, tough, and grey structure with a concave shape (Evans 1993; Heine 2004; Kumar 2005; Cole 2009).

The tympanic cavity is separated from the external ear by the tympanic membrane and from the inner ear by the vestibular and cochlear windows. It is divided into three parts: the tympanic bulla within the temporal bone, ventrally; the epitympanic recess, dorsally; and the tympanic cavity proper, which connects the two other parts (Tobias 2013a). The epitympanic recess contains a chain of three auditory ossicles (Singh 2018), occupied almost entirely by the head of the malleus and the incus ossicles (Evans and Lahunta 2013). The tympanic cavity proper includes the tympanic membrane in its lateral wall and opens rostrally into the nasopharynx via auditory tube (Singh 2018). The tympanic bulla forms the bottom and a great part of the lateral wall of the tympanic cavity. The medial wall contains two windows, a round cochlear window that leads to the cavity of the cochlea, and an oval vestibular window that connects with the internal ear (König and Liebich 2004). The tympanic bulla is an enlarged bulbous extension of the temporal bone and varies in prominence depending on the species. Its function is not totally clear but it is related to the improvement of the perception of very low and very high frequencies sounds (Singh 2018). The tympanic bulla may be compared to an eggshell, having an elliptical opening on the dorsal side that communicates with the tympanic cavity proper (Evans and Lahunta 2013).

The auditory ossicles are the smallest bones in the dog’s body (Sturtz and Asprea 2012). These three bones transmit air vibrations from the tympanic membrane passing through the middle ear cavity to the inner ear (Evans and Lahunta 2013). Extending from the tympanic membrane to the oval cochlear window this three ossicles are: the malleus (hammer), the incus (anvil), and the stapes (stirrup) (Akers and Denbow 2013). These ossicles are mobile, made of compact bone, formed by endochondral ossification, and connected with each other by synovial joints (Kumar and Roman-Auerhahn 2005). The sound waves travel through the auditory canal and make the tympanic membrane vibrate, which leads to the vibration of the first small bone, the malleus. The vibration is transmitted from all the small bones to the oval cochlear window, place where the vibrations transfer the sound stimulus to the inner ear (Moyes and Schulte 2014).

The auditory tube or eustachian tube, is a short canal that extends from the nasopharynx to the tympanic cavity (Evans and Lahunta 2013), connecting the middle ear with the nasopharynx (König and Budras 2007). The bony wall of the tube is formed rostrally by the squamous portion of the temporal bone, and ventrally by its tympanic portion (Evans and Lahunta 2013). The auditory tube is divided into three parts: a cartilaginous part that opens into the nasopharynx; an osseous part, which opens into the middle ear; and a junctional part, where the two other portions connect (Bluestone 2005; Njaa et al. 2012).

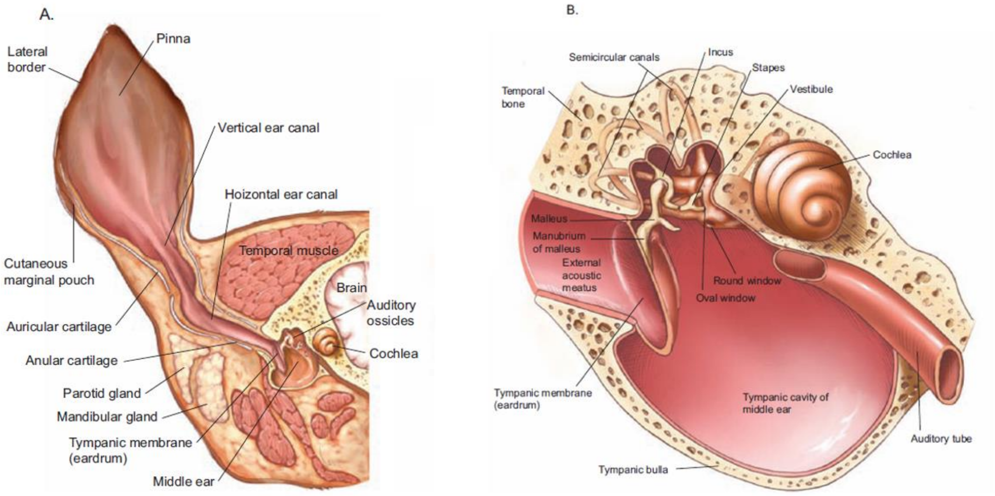


Figure 1 - Anatomy of the ear A. Coronal section of the head and external ear B. Middle and inner ear (Adapted from McCracken et al. 2008 with permission).

4. Otitis Introduction

Otitis is considered one of the most frequent motives of consultations in small animal clinic (Scott et al. 2001; Bensignor et al. 2017). It is usually seen as a consequence of an underlying disease, therefore the investigation of the ear disease is part of the dermatology speciality (Bensignor and Forsythe 2012). Depending on the history and clinical signs observed it is important to identify the depth of the inflammation, classifying it in otitis externa, media or interna (Carlotti and Tailleu 1997; Bensignor et al. 2000; Bensignor et al. 2017).

Otitis externa is an inflammation of the epithelium of the vertical and/ or horizontal ear canals and its surrounding structures (Fossum and Caplan 2013). This inflammation can affect the external ear canal, from the pinna to the tympanic membrane (Carlotti and Tailleu 1997; Bensignor et al. 2000; Bensignor et al. 2017). Otitis media implies inflammation within the middle ear (Harvey et al. 2001) and it is often secondary or an extension of otitis externa. In dogs, primary otitis media is very rare (Cole et al. 1998; Bensignor et al. 2017). Otitis interna is an infection of the inner ear that usually occurs as an extension of otitis media (Axlund 2005).

4.1 Aetiology and pathogenesis

Otitis is not only a local phenomenon of ear infection (August 1988; Griffin 1933; Bensignor et al. 2017) and it usually has a multifactorial aetiology (Roth 1988; Bensignor et al. 2017). Initially the pathogenesis involves inflammation of the ear canal (erythematous phase). This phenomenon is usually acute and not noticed by the tutor unless the animal shows pain or pruritus. This phase is followed by hyperplasia of the epithelium and the ceruminous glands, causing excess of cerumen production (ceruminous phase). The anatomic and inflammatory modifications in the ear allow changes in its microenvironment which becomes favourable to the growth of commensal microorganisms such as *Staphylococcus spp*. and *Malassezia spp*. This leads to further inflammation and perpetuates otitis (Roth 1988; Bensignor et al. 2017). In chronic cases, there is epidermal hyperplasia and sometimes ulceration as well, particularly in dogs with secondary infection. Due to the hyperplasia and dilatation of the apocrine glands the ear canal narrows or closes completely. An inflammatory infiltrate develops, followed by fibroplasia, which exacerbates obstruction (Makeover 1993; Bensignor and Forsythe 2012). Ossification of the cartilages and skin may occur in long-term cases. However, the occurrence of otitis does not always follow these phases. Otitis media develops when the tympanum is ruptured and the bacterial infection can involve the tympanic bulla (Bensignor et al. 2017).

The causative factors of otitis externa have been classified into primary, predisposing, and perpetuating (Scott et al. 2001; Saridomichelakis et al. 2007). Primary factors are responsible for inflammation of the ear canal and are able to cause otitis directly (Roth 1988; Bensignor et al. 2017). These factors can be intensified or complicated by predisposing and perpetuating factors (Scott et al. 2001; Rosser 2004; Saridomichelakis 2004; Saridomichelakis et al. 2007). Predisposing factors are the ones that change the environment of the ear canal and create an increased risk for development of otitis externa (Bajwa 2018) however they do not cause otitis externa directly (Scott et al. 2001; Rosser 2004; Saridomichelakis 2004; Saridomichelakis et al. 2007). Perpetuating factors are responsible for chronicity (Roth 1988; Bensignor et al. 2017) where progressive pathological changes occur in the ear canal, tympanic membrane and middle ear, preventing the resolution of otitis (Scott et al. 2001; Rosser 2004; Saridomichelakis 2004; Saridomichelakis et al. 2007). The recognition of these causes or factors is important to avoid treatment failures (Griffin 2010; Miller et al. 2013).

4.2 Primary causes

Different parasites have been associated with otitis externa, especially *Otodectes* spp., but also *Demodex* spp., and *Sarcoptes* spp. (Bensignor and Legeay 2000; Hill et al. 2006; Saridomichelakis et al. 2007; Miller et al. 2013). Initially, the exudate colour is dark brown to black. However, in chronic cases if the ear is secondarily infected with bacteria or yeast, the exudate becomes ceruminous or purulent (Rosser 2004). Infested animals show intense itching and discomfort, and often develop otitis externa with erythema and ceruminous exudate (Curtis 2004; Souza et al. 2013). *Otodectes cynotis* is a psoroptid mite that causes otoacariasis in dogs (Griffin 1981; August 1988). *Demodex canis* can cause a ceruminous otitis (Hnilica and Patterson 2017) with or without concurrent skin lesions or demodicosis (Rosser 2004). Other parasites that may cause inflammation on the pinnae or near it, provoking head shaking, ear itching, and leading to secondary otitis externa, include *Otobius megnini* (spinous ear tick), *Sarcoptes scabiei*, *Cheyletiella* spp., and *Eutrombicula* spp. (chiggers) (Rosser 2004).

Foreign bodies may be another primary cause, being more common in young hunting breed dogs that present an acute, unilateral and painful otitis externa, without any history of previous ear disease (Paterson 2013). Chaff, dirt, small stones, impacted wax, broken hair or dried medication are some typical foreign bodies that may be found in the ear canal. Sometimes the foreign body is not identifiable because it becomes covered with cerumen (Hnilica and Patterson 2017), but it is usually found by otoscopy. Nevertheless, the strange material may migrate into the profoundest portions of the vertical canal, causing rupture of the tympanic membrane and leading to otitis media (Paterson 2013).

Otitis externa caused by allergic diseases can be associated with atopic dermatitis. It may be unilateral or bilateral. When there is an acute allergy the ear canal becomes erythematous, hyperplastic and with exudation. Part of the tympanic membrane may also appear swollen and oedematous. In chronic cases the ear canal becomes narrowed and suffers erosion, ulceration, exudation and secondary infection (Paterson 2013).

Epithelization disorders such as primary idiopathic seborrhoea, sebaceous adenitis, zinc responsive dermatosis, vitamin A responsive dermatosis, and the idiopathic inflammatory otitis of the Cocker Spaniel are some primary causes of otitis externa (Harvey and Paterson 2014). Endocrine diseases such as hypothyroidism, hyperadrenocorticism, and sex-hormone imbalances may also cause an alteration in the keratinization and cerumen production of the ear canal, resulting in a seborrheic and ceruminous form of otitis externa (Rosser 2004).

Endocrinopathies are frequently referred as underlying causes of chronic ceruminous otitis externa (Ling et al. 1979; White et al. 1989; Pancierra 1993; Harvey and Paterson 2014). Gonadal hormone alterations (due to a Sertoli cell tumour for example) may have a profound effect on the cutaneous glandular function and possibly be associated with ceruminous otitis (Schmeitzel and Lothrop 1990; Harvey and Paterson 2014).

Immuno-mediated otitis externa is hardly ever an isolated entity. It is usually associated with other cutaneous lesions spread on the animal's body (Scott 1980; Scott et al. 1980; Manning 1982; Roth 1988). The autoimmune skin diseases that may affect the external ear canal include pemphigus foliaceus, pemphigus erythematosus, discoid lupus erythematosus, cutaneous vasculitis, bullous pemphigoid, and mucous membrane pemphigoid. These are all rare causes of otitis externa, and usually there are skin lesions at other locations of the body or lesions on various mucous membranes. Otitis can also be one of the first skin related signs of leishmaniosis (Rosser 2004).

4.3 Predisposing factors

Some studies suggested that both the ear conformation (pendulous or erect) and the amount of hair could affect the retention of heat and humidity in the ear canal and therefore predispose for otitis externa (Berg 1951; Tufvesson 1955; Sharma and Rhoades 1975; Hayes et al. 1987). Dogs with pendulous pinna have a restrict circulation of air within the ear canal (Rausch and Skinner 1978; August 1988) and although Labrador Retrievers and Cocker Spaniels are over-represented breeds with otitis externa, not all dogs with pendulous pinna develop otitis (Baba et al. 1981; August 1988). Conversely, the German Shepherds and other upright pinna breeds, appear to be especially prone to otitis externa (Griffin 1993; Murphy 2001). The ear canal anatomy of the dog is unusually narrow (Wilson 1985; August 1988) which is not favourable to the normal expulsion of secretions and predisposes to recurrent infections (August 1986; Van der Gaag 1986; August 1988). Excessive hair or knots within the ear canal may also cause occlusion and interfere with adequate drying of the ear. The disproportionate moisture created by hair predisposes some breeds such as Poodles and Terries to otitis externa. When long hairs become matted and tangled, cerumen, exudates, and other secretions create a hair mass and the ear canal suffers occlusion (Gotthelf 2005).

Excessive accumulation of water due to regular swimming or bathing may lead to maceration of the ear canal *stratum corneum* (Rosser 2004). The disproportionate moisture causes rehydration of the cornocytes and destroys the protective lipid barrier of the *stratum corneum* (Pelton and Klein 1988; Logas 1994) which allows the resident microflora to become opportunistic and initiate otitis (Logas 1994). When the ear canal gets recurrently wet the ceruminous glands are stimulated, causing a ceruminous otitis externa (Rosser 2004).

Iatrogenic factors include the use of cotton swabs for ear cleaning, traumatic removal of hair from the ear canal, incorrect topical or systemic antibacterial treatment predisposing to resistant strains of opportunistic bacteria, and the use of irritating solutions such as ear rinses and cleaners (Rosser 2004).

Obstructive ear diseases such as inflammatory polyps and tumours may be a cause of otitis externa because when there is an obstruction within the ear canal, it prevents the exudate drainage, which predisposes the ear to secondary infection (Rosser 2004). If a dog with chronic otitis externa does not respond to routine therapy, the clinician should consider the possibility of a tumor or mass growth. Occlusions of the ear canal due to a tumor usually cause pain, discomfort (Gotthelf 2005), and a bloody exudate may be present (Fossum and Caplan 2013).

Otitis media is often considered as a perpetuating factor of otitis externa, because it usually occurs in dogs as an extension of otitis externa. However, some cases may start with primary otitis media that after causes rupture of the tympanic membrane and results in otitis externa. Primary otitis media may result from ascending nasal or respiratory infections through the auditory tube, or from haematogenous spread (Stern-Bertholtz 2003; Owen et al. 2004; Hayes et al. 2010; Miller et al. 2013).

4.4 Perpetuating factors

Bacteria and yeast are considered to be simultaneously predisposing and perpetuating factors of otitis externa and media (Cole 1998; Bourély et al. 2019). Most microorganisms isolated from inflamed ears are part of the normal microflora but have become opportunistic (Scott et al. 2001, Rosser 2004; Zur et al. 2011) and in most cases, more than one species is isolated (Graham-Mize and Rosser 2004; Zur et al. 2011). *Staphylococcus* spp., *Streptococcus* spp., *Pseudomonas* spp., *Proteus* spp., and *Escherichia coli* are the most common isolated bacteria (Scott et al. 2001; Greene 2006; Malayeri et al. 2010). The most common isolates in acute disease are *Staphyloccus* spp. and *Streptococcus* spp., and in chronic cases the most common are *Enterococcus* spp., *Corynebacteria* spp., *Pseudomonas* spp., *Proteus* spp., *Escherichia Coli* and *Bacteroides* spp. (Paterson 2020). Gram-positive infections have a typical yellow purulent discharge, and the wall of the ear canal becomes erythematous, oedematous, hyperplastic, and pruritic. In chronic cases the tympanic membrane may be ruptured. Gram-negative infections have a characteristic yellow or green malodorous mucoid discharge. The wall of the canal is usually erythematous, ulcerated, painful, and in chronic cases the eardrum is rarely intact (Paterson 2013).

Malassezia pachydermatis is the most isolated yeast due to its fast multiplication during favourable conditions (Crespo 2002; Miller et al. 2012; Chiavassa et al. 2014). Anatomical anomalies creating stenosis, increased cerumen secretion or retention, moisture, and inhibition of air circulation are factors that predispose to *Malassezia* spp. (Bond et al. 2010; Chen and Hill 2005; Chiavassa et al. 2014). Yeast infection has a typical thick ceruminous discharge and the wall of the ear canal becomes oedematous, hyperplastic and pruritic. In chronic cases hyperplasia of the ceruminous glands may lead to narrowing of the lumen (Paterson 2013).

If there is chronic inflammation, the auditory cartilage becomes fibrotic, calcified and ossified, leading to stenosis of the ear canal, therefore secretions, desquamated cells, and microorganisms stay entrapped within the ear. Calcified cartilage is a permanent alteration and cannot be treated medically (Hnilica and Patterson 2017).

Otitis media occurs secondarily to chronic otitis externa in up to 50% of the dogs (Shell 1988; Belmudes et al. 2018; Bajwa 2018) which may be due to bacterial infection, or foreign bodies within the ear canal that perforate the tympanic membrane (Paterson 2013). The absence or rupture of the tympanic membrane is suggestive of otitis media however an intact tympanic membrane does not rule out otitis media (Cole et al. 1998; Bajwa 2018).

4.5 Signalment

In young dogs, allergy, particularly atopic dermatitis, is the most common trigger of otitis. Otic demodicosis is an unusual cause of ear disease in the dog. Other primary causes affecting young animals include primary idiopathic seborrhoea and immunomediated diseases. In older animals, systemic diseases such as hypothyroidism, hepatic, renal, and pancreatic diseases may also predispose to ear infection (Paterson 2020). Otitis is more severe when it is first diagnosed in older dogs. Almost all the dogs with more than five years old have cocci and rods at significantly higher levels, which can be explained by chronic changes and the possibility that otitis media was not diagnosed when they were younger (Zur et al. 2011).

Certain breed characteristics may predispose to otitis externa (Figure 2) (Paterson 2020). Cocker Spaniels have a higher risk of developing the disease due to their proliferative changes in the horizontal ear canal and pendulous pinna (Hayes and Pickle 1987; Angus et al. 2002). Other dogs with pendulous pinnae such as Basset hounds, and Bloodhounds are predisposed to otitis, as are breeds such as the Shar-pei which have narrowed ear canals. Otitis externa triggered by atopic dermatitis is frequently seen in breeds like West Highland white terrier, Staffordshire bull terrier, Labrador retriever, German shepherd, and Boxer. Otitis due to cutaneous adverse food reactions is more usual in the Labrador retriever. Juvenile-onset demodicosis is frequently seen in the Shih Tzu, American Staffordshire terrier, English bulldog, and Boxer. Keratinization disorders are often breed linked, for example sebaceous adenitis of the Akita and Poodle, primary seborrhoea of the Cocker spaniel and zinc-responsive disease of the Siberian husky and Malamute (Paterson 2020).

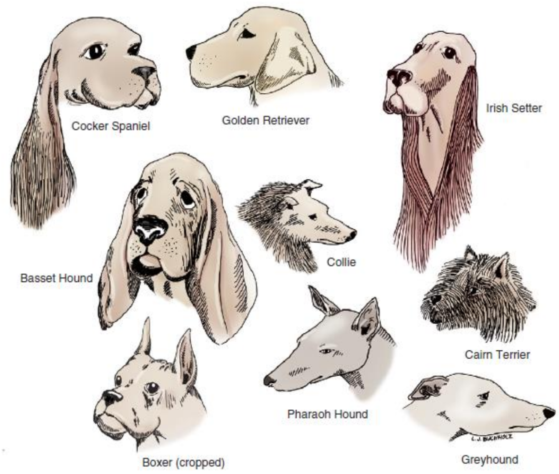


Figure 2 - The ear conformation varies according to the dog's breed, as well as its size and shape (Adapted from Evans and Lahunta 2013 with permission).

5. Otitis Media Diagnosis

5.1 History and Clinical Signs

A wisely taken history helps to establish the diagnosis of otitis media before the examination of the ear (Paterson 2013). Most animals that develop otitis media secondary to otitis externa are middle-aged (Fossum and Caplan 2013) and frequently have a history of recurrent or chronic external ear infections (Gotthelf 2004). The history and clinical signs of symptomatic animals with otitis media are similar to those with otitis externa. If a foreign body is trapped in the ear, head shaking and scratching with the paws are typical signs. Head shaking and pruritus are also common among animals with parasitic and bacterial infection. A purulent, odoriferous discharge may be present in cases of chronic infection. Rubbing the head on objects and show pain when the ear is palpated are other signs of otitis media (Fossum and Caplan 2013). Otohematoma is also frequently present in dogs with otitis. Reluctance to open mouth, catch a ball, chew solid food, yawn, or bark are signs associated with pain on opening the temporomandibular joint. Hearing or deafness problems may be noticed due to pain when the pinna is palpated. When a dog demonstrates pain by whining, holds the head to one side, rubs the face along the floor or scratches at ears, facial nerve damage may be the cause. Losing food out of the mouth may be related with a sympathetic nerve damage named Horner's syndrome (Paterson 2013). Neurological signs are less common but may include head tilt, ataxia, Horner's syndrome or facial nerve paralysis (Little et al. 1991; Bruyette and Lorenz 1993; Parker and Chrisman1995; Harvey and Paterson 2014). Other signs observed are pharyngitis, tonsillitis, or discharge through auditory tube, and also lymphadenopathy in severe or chronic cases (Rhodes and Werner 2011).

5.2 Physical Examination

A complete physical examination should always be performed to detect signs of systemic disease or infections (Shell 1988) since they may predispose to otitis externa (Joyce 2010). Ear diseases are often a reflection of dermatologic diseases therefore a dermatologic examination should be done as well (Rosychuk 1994). Discharge from the external auditory canal, hyperplasia, and ulceration of the auditory epithelial tissue are usually obvious on examination of dogs with otitis media (Fossum and Caplan 2013). The temporomandibular joints and base of the ears should be palpated to feel the presence of swelling, lumps, or pain (Denny 1973; Shell 1988). The pharyngeal area should be observed for signs of inflammation or masses that may have spread to the middle ear via the auditory tube (Chrisman 1979; Shell 1988). Neurologic signs are not frequent in most dogs with otitis media but must be ruled out (Fossum and Caplan 2013). Then, the external ear canal has to be examined in more detail by otoscopy (Shell 1988).

5.3 Otoscopic examination

Otoscopy is very useful in the diagnosis of otitis media (Sobel 2017) and can be done with a handheld otoscope or a video otoscope (Cole 2004). If the patient shows lack of compliance the ear should be examined under general anesthesia. Sedation is rarely used in inflamed ears and conscious examination is never adequate in chronic cases (Joyce 2010). This examination may be painful and invasive (Layne and de Miguel Garcia 2019) therefore regional anaesthesia with local nerve blocks is a great pain management technique once it blocks (Buback et al. 1996; Kona-Boun et al. 2006; Richman et al. 2006; Layne and de Miguel

Garcia 2019) the great auricular and the auriculotemporal nerves, that provide sensory innervation to the ear canal and pinna in dogs (Martinez et al. 2018; Stathopoulou et al. 2018; Layne and de Miguel Garcia 2019). During the otoscopy, the clinician should evaluate the condition of the ear canal (presence of erythema, stenosis, proliferation, and ulceration), look for any foreign bodies or masses, observe the existence, consistency, and colour of any exudate, and evaluate the patency of the tympanic membrane (Cole 2004). In case of otitis media an intact tympanic membrane is seen as a bulging opaque tissue with purulent or haemorrhagic fluid or gas (Figures 3 and 4). When the tympanic membrane is ruptured there is a discharge into the ear canal or bullae filled with debris (Rhodes and Werner 2011). If the tympanic membrane is ruptured, the animal has otitis media (Cole 2004). However an intact tympanum does not exclude otitis media and may be found in up to 72.5% of the cases (Cole et al. 2002; Cole 2004). Definitive diagnosis requires cytology (Fossum and Caplan 2013).

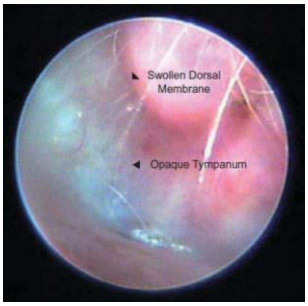


Figure 3 - Video otoscopy where purulent fluid is observed in the tympanic bulla (Adapted from Rhodes and Werner 2011 with permission).

Figure 4 - Video otoscopy of otitis media where haemorrhagic fluid is observed (Adapted from Rhodes and Werner 2011 with permission).

5.4 Cytology, Bacterial culture and Antibiotic sensitivity testing

If the tympanic membrane is ruptured, samples for cytology and culture should be obtained from the middle ear cavity using a sterile swab introduced into the horizontal ear canal. If the tympanic membrane is abnormal, it is necessary to perform a myringotomy (incision into the tympanum) to obtain samples and allow flushing and drainage of the middle ear cavity (Cole 2004). A myringotomy is done when otitis media is suspected (Gortel 2004), the tympanum is intact and there is evidence of infection within the middle ear that did not respond or continue to recur even with appropriate systemic therapy and ear flushing. In most of these cases, the tympanum was perforated before but has healed (Griffin 2006). A myringotomy may be performed for diagnostic and therapeutic purposes (Gortel 2004).

The microbial examination of samples from different regions of the canine ear has revealed a variety of isolates and susceptibility patterns (Henderson and Radasch 1995; Cole et al. 1998; Vogel et al. 1999; Hettlich et al. 2005) therefore if concurrent otitis media is present, the exudate of the middle ear should be cultured separately because different organisms and sensitivity patterns often occur (Cole et al. 1998; Jacobson 2002). The appropriate diagnosis of otitis media requires cytology once it determinates the type and number of microorganisms present (Scott et al. 2001; Murphy 2001). Culture and antibiotic sensitivity testing are not a routine part of the diagnostic plan and should not be done without cytology first to demonstrate the presence of bacteria and inflammatory cells. The most common indications for culture and antibiotic sensitivity testing are cases of otitis media or severe otitis externa by rods when systemic therapy has to be prescribed. In cases of topical therapy used alone, culture and antibiotic sensitivity testing are not worth doing, because resistance to a particular antibiotic in vitro may not correlate to its clinical response, once topical application of an antibiotic results in a higher concentration than the one that could be achieved with systemic medication (Murphy 2001).

5.5 Imaging of the ear

5.5.1 Radiography

Radiography is indicated in refractory or recurrent cases of otitis externa, in which otitis media is suspected, and also in cases of surgical intervention (Murphy 2001). Radiographic features of otitis media include increased radiopacity of the normally air-filled bulla, size enlargement of the bulla, and thickening of the bulla's wall (Geary 1965; Shell 1988; Lee 1995; Garosi et al. 2003). Other aspects found are multiple calcified fragments within the tympanic bulla (Farrow 1992; Garosi et al. 2003), narrowing of the external ear canal (Figure 5) and/or ossification of the annular cartilages (Shell 1988; Garosi et al. 2003). Radiography is frequently used, but normally lacks sensitivity (Garosi et al. 2003) and it is of limited use in diagnosing otitis media because although chronic changes of the bulla can be identified (Murphy 2001) it is technically challenging, time-consuming and hard to interpret (Lorek et al. 2020).

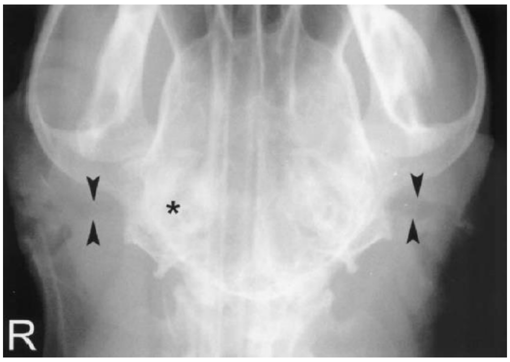


Figure 5 - Ventral dorsal radiography of a Doberman diagnosed with chronic bilateral ear infections. Both external ear canals (arrowheads) are narrowed and tortuous. There is an increased opacity in the right tympanic bulla and petrosal portion of the temporal bone (asterisk) (Adapted from Solano 2005 with permission).

5.5.2 Computed Tomography (CT)

Compared to radiography, CT is slightly more sensitive for imaging the dog's middle ear (Hoskinson 1993; Love et al. 1995; Dvir et al. 2000) since radiography fails to detect early otitis media alterations (Hoskinson 1993; Dvir et al. 2000). CT is also better at detecting subtle increases in soft tissue opacities (fluid or mass) in the tympanic bulla (Love et al. 1995) as well as differentiating fluid within the tympanic bulla from thickening of its walls (Solano 2005). Other advantages of CT over radiography, include elimination of superimposed overlying structures and superior soft tissue contrast (Hoskinson 1993; Love et al. 1995; Rohleder et al. 2006). Common findings of otitis media include thickening of the external ear canal, with or without mineralization (Solano 2005). Thickening, irregularity (Bischoff and Kneller 2004) enlargement, sclerosis (Solano 2005), and lysis can be observed in the tympanic bulla and also soft tissue density representing fluid or tissue within the lumen (Figure 6) (Bischoff and Kneller 2004). Pathological alterations also include periosteal proliferation on the temporal bone (Foster et al. 2014; Salgüero et al. 2016). The presence of bulla wall thickening may be considered an irreversible alteration and indication for TECA-LBO (Doyle et al. 2004; Belmudes et al. 2018).

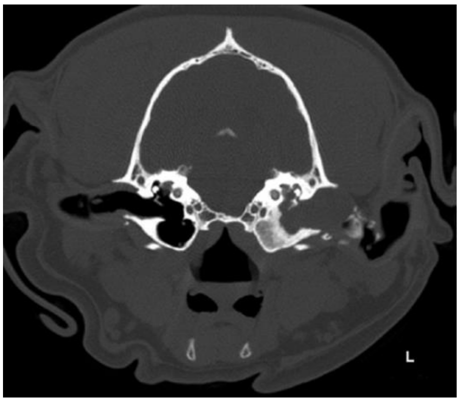


Figure 6 - Transverse CT of a dog with chronic otitis externa and media. There is proliferative bone in the left tympanic bulla as well as soft-tissue opacity material in the bulla and distal external ear canal. The opening into the bulla has a widened appearance and the external ear canal cartilages have mineralization (Adapted from Hathcock 2013 with permission).

5.5.3 Magnetic Resonance Imaging (MRI)

Due to limited accessibility and high cost, MRI is less used than radiography and CT in the diagnosis of otitis media (Bischoff and Kneller 2004). The most common abnormalities in otitis media are the presence of hyperintense material within the tympanic bulla on T2-weighted sequences (Allgoewer et al. 2000; Dvir et al. 2000; Solano 2005) which is compatible with accumulation of fluid. The enhancement of the bulla's inner surface is visible, probably due to inflammation, on T1-weighted sequences after injection of contrast material (Garosi et al. 2003; Solano 2005). Material within the bulla appears isointense compared to the cortex on T1-weighted, and hyperintense on T2-weighted (Allgoewer et al. 2000; Garosi et al. 2001; Owen et al. 2004). A laminated aspect in the tympanic bulla's mucosa on T2-weighted images has also been described (Dvir et al. 2000; Bischoff and Kneller 2004) and may represent chronic disease, with hypointense areas of fibrous tissue (Bischoff and Kneller 2004).

6. Treatment of Otitis

The main treatment principles of otitis are: cleaning the ear, decreasing inflammation, treating otic infections, treating concurrent skin disease if present, and plan a maintenance otic therapy to prevent recurrence (Cole 2014a).

6.1 Cleaning

Ear cleaning is important to maintain the normal otic environment and help in the treatment of otitis (Nuttall and Cole 2004). In dogs with otitis media, a deep ear flushing at the clinic is necessary to clean the ear entirely, visualize the ear canal, and evaluate the tympanic membrane. Glucocorticoids are usually indicated before the ear flush (Cole 2014a) because they reduce pruritus, pain, swelling, exudation, tissue proliferation, and stenosis (Nuttall 2014). Ear cleaning or flushing can also be done at home with a commercial solution in a squeeze bottle (Logas 2014) by simply introducing the cleaning fluid directly into the ear and massaging the ear canals (Nuttall and Cole 2004). If there is a great deal of purulent material, a bulb syringe should be used instead (Logas 2014) so the fluid can be squeezed in under pressure and dislodge any debris present (Nuttall and Cole 2004). The frequency of flushing recommended for home care depends on the severity of infection, consistency of the discharge, chronicity of the otitis, presence of yeast or bacteria, and also if the tympanum is ruptured or intact (Logas 2014). The product and the ear cleaning technique also depend on the patient and may change as treatment progresses (Nuttall and Cole 2004).

Most ear cleaning products have a good antibacterial action which enhances the effectiveness of the antimicrobial agents (Barnard and Foster 2018). Ceruminolytics (organic oils and solvents) soften and dissolve cerumen and debris. Surfactants (sodium docusate and other detergents) emulsify debris and keep it in solution. Astringents (alcohols, boric acid and acetic acid) help prevent maceration by drying the surface of the canal. Anti-inflammatories (glucocorticoids) are helpful because they can inhibit inflammation and pruritus (Nuttall and Cole 2004; Swinney et al. 2008).

6.2 Topical Therapy

Topical therapy alone may be a viable option for the treatment of otitis media in dogs, however it is only successful if followed by a thorough lavage of the tympanic bulla (Palmeiro et al. 2004). In some cases otitis may be treated empirically with products that contain broad-spectrum antibiotics (Henneveld et al. 2012). It is possible to select antibiotics only based on cytology if there is knowledge of prevalent bacteria causing otitis and their antimicrobial susceptibility patterns. In recurring or refractory cases, culture and antibiotic sensitivity testing are essential to select the appropriate antimicrobial (Malayeri et al. 2010). Topical therapy is particularly helpful because the drugs reach their highest concentrations in the ear with the fewest systemic effects (Greene 2006; Malayeri et al. 2010). In all cases, the clinician must try to select drugs with the lowest potential for ototoxicity, having in mind that failure to treat infection adequately may lead to hearing loss and vestibular disease due to the bacterial exotoxins (Stenqvist et al. 1997; Paterson 2017).

The majority of ear infections in dogs are a combination of bacteria and yeasts (Jordan 2001; Gotthelf 2004), so in order to fight this mixed infections, the otic products are also a combination of corticosteroids and antimicrobials (Mendelsohn 2014). Fungi otitis, caused by *Malassezia pachydermatis* are treated with either: polyenes such as nystatin (Rosychuk 1994;

Morris 2004); azoles like thiabendazole, clotrimazole and miconazole, the most commonly used in veterinary medicine (Tom 2000; Morris 2004); and allylamines such as terbinafine (Gupta et al. 2000; Morris 2004). When it comes to treat bacterial infections the aminoglycosides are the most used antibiotics present in topical products (Plumb 2002; Morris 2004). Neomycin is a first-line antibiotic often chosen to treat gram-positive infections (Mendelsohn 2014). Gentamicin is a second-line antibiotic used to treat gram-positive cocci and gram-negative bacteria, having some resistant strains of *Pseudomonas aeruginosa* and *Escherichia coli* (Strain et al. 1995; Morris 2004). Amikacin and Tobramycin are third-line antibiotics normally used to treat chronic or recurrent otitis caused by resistant strains of gram-negative bacilli, especially *Pseudomonas aeruginosa* (Morris 2004). Fluoroquinolones such as enrofloxacin and marbofloxacin are used for both gram-positive and gram-negative bacteria (Mendelsohn 2014), having a spectrum of activity against *Pseudomonas aeruginosa* (Morris 2004). Polymyxins are broad-spectrum antibiotics with activity against all gram-negative bacteria (except *Proteus* spp.). These antibiotics are synergistic with miconazole against gram-negative bacteria and *Malassezia pachydermatis*. Silver sulfadiazine is also a broad-spectrum antibiotic, having activity against *Pseudomonas aeruginosa* and some anti yeast activity as well (Mendelsohn 2014). Osurnia and L-Mesitram are also efficient topic options for the management of otitis in dogs.

6.3 Systemic Therapy

Systemic antimicrobial therapy based on culture and antibiotic sensitivity testing is recommended in dogs with otitis media (Logas 1994; Colombini et al. 2000) although it may not achieve therapeutic concentrations if there is a great amount of exudate and debris in the infected ear canal (Morris 2004; Guardabassi et al. 2008; Guardabassi et al. 2010) where the infectious organisms are logged and form a biofilm. Therefore a successful treatment is better if accomplished by topical therapy for a minimum of 6 to 8 weeks. The treatment should be stopped only when the cytology is negative for microorganisms, the epithelium of the ear canal has normalized and there is no residual oedema. In most cases there is also regeneration of the tympanic membrane (Morris 2004). When topical therapy is unsuccessful due to inaccessibility of the middle ear, for example stenosis of the canal or excessive discharge that prevents adequate penetration of topical medication, systemic medication is useful (Harvey and Paterson 2014). Once the most common bacteria isolated from dogs with otitis media is *Staphylococcus pseudintermedius*, a good empiric choice is cephalexin or amoxicillin trihydrate/ clavulanate potassium (Cole 2014b). For challenging *Pseudomonas aeruginosa* infections most clinicians recommend starting the treatment with an oral fluoroquinolone (Carlotti et al. 1998; Cole 2014b). In cases of multidrug-resistant *Pseudomonas aeruginosa* infections, aggressive therapy with systemic β-lactam antibiotics may be considered (Cole

2014b). Otic yeast infections usually require topical therapy in addition to systemic, (Pinchbeck et al. 2002; Cole 2014b) and both ketoconazole and itraconazole have been used in dogs (Cole 2014b).

6.4 Surgical Therapy - Total Ear Canal Ablation and Lateral Bulla Osteotomy

When otitis media is established, the tympanic membrane and ear canal epithelium become thickened and hyperplastic, and the cartilage suffers dystrophic calcification. In end-stage middle ear infection, the tympanic bulla suffers osseous alterations, which serves as a resistant source of infection. If in addiction, medical therapy is no longer effective and there are signs of chronicity, surgical therapy is indicated (Smeak and Inpanbutr 2005).

Total ear canal ablation (TECA) combined with lateral bulla osteotomy (LBO) is the gold standard treatment of most end-stage ear diseases such as otitis media (White and Pomeroy 1990; Spivack et al. 2013; Smeak 2016). TECA surgery involves the removal of the vertical and horizontal ear canals cartilage and epithelium (Seward et al. 1958; Singh and Rao 1959; Smeak and DeHoff 1986). When otitis externa is complicated by otitis media, the ear canal ablation alone may be inadequate because it does not allow drainage of the middle ear, and infection or fistulation may occur (Grono 1962; Smeak and DeHoff 1986; Sharp 1990). Therefore if otitis media is present, middle ear drainage should follow ablation (Harvey 1985; Sharp 1990) since poor results and complications were reported when TECA was performed without bulla osteotomy (Seward et al. 1958; Smeak and DeHoff 1986; Mason et al. 1988).

The middle ear is surgically accessible with lateral and ventral approaches (Boothe 1988) however TECA combined with LBO is the most common technique used for accessing the tympanic cavity (Smeak 1998; Smeak and Inpanbutr 2005), and TECA is always performed first, because it facilitates the LBO (Boothe 1988). TECA-LBO surgery is successful if the entire external ear canal is excised, along with the complete removal of debris and abnormal epithelium within the ear canal and tympanic cavity (Smeak and Inpanbutr 2005; Smeak 2016). Nowadays, TECA-LBO surgeries are expected to permanently resolve signs of chronic ear disease in up to 93% of dogs (Doyle et al. 2004; Smeak 2011).

6.4.1 Total Ear Canal Ablation (TECA)

To perform TECA (Figure 7) the animal should be positioned in lateral recumbence with the head elevated (Fossum and Caplan 2013). Although the ear canal is difficult to prepare aseptically and contamination is inevitable (Vogel et al. 1999; Smeak 2013) the pinna and surrounding skin should be cleaned aseptically (Fossum and Caplan 2013). The skin incision is T-shaped, with the horizontal part parallel and below the upper edge of the tragus. Then, the vertical part is done perpendicularly from the midpoint of the horizontal one (Smeak 2014). Soft tissues surrounding the ear canal are gently dissected free from the cartilage (Bacon

2018) and the lateral aspect of the vertical canal becomes exposed. During the dissection it is important to avoid damaging the facial nerve (Figure 8) and also the major branches of the great auricular artery, staying as close as possible to the cartilage of the ear canal (Fossum and Caplan 2013). With a curved Metzenbaum scissors, bluntly dissection around the proximal and medial portion of the vertical canal is preformed (Smeak 2014). The horizontal incision around the opening of the vertical ear canal should be continued and the excision of the horizontal canal attached to the external acoustic meatus can be done with a scalpel blade, or Mayo scissors (Fossum and Caplan 2013). The thickened, hyperplastic epithelium is then debrided from the meatus with a curette to outline the opening into the tympanic bulla (Bacon 2018). The tissue collected is sent for culture and susceptibility testing (Smeak 2014).

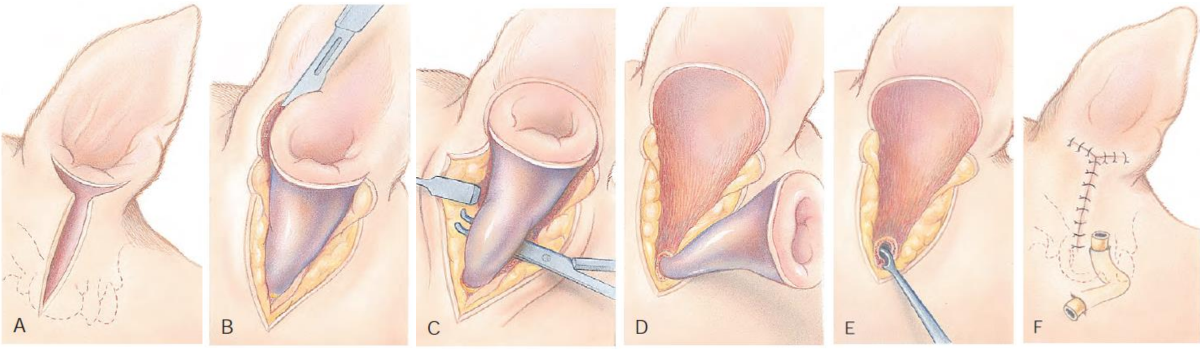


Figure 7 - Total ear canal ablation (TECA) A. T-shaped incision B. Retraction of skin flaps and incision around the opening of the vertical ear canal C. Dissection around the vertical ear canal D. Dissection to the level of the external acoustic meatus E. Excision of the horizontal ear canal and secretory tissue F. Penrose drain and closure of subcutaneous tissue and skin (Adapted from Fossum and Caplan 2013 with permission).

6.4.2 Lateral Bulla Osteotomy (LBO)

Although LBO exposes less the tympanic cavity than the ventral bulla osteotomy, it does not require reposition of the animal and is preferred when combined with TECA (Fossum and Caplan 2013). This part of the procedure starts by elevating soft tissues from the lateral wall of the bulla with a periosteal elevator, and removing it with a rongeur or a burr (Tobias 2013b). Stray dissection along the bulla wall should be avoided, in order to prevent damages in the retroglenoid vein, carotid artery and maxillary vein (Bacon 2018). Dissection continues on the lateral and ventral aspects of the bulla until the caudal aspect of the middle ear canal is exposed (Fossum and Caplan 2013). Rongeurs can then be used to remove the external osseous prominence and create space to curettage the bulla floor, place where the epithelium is commonly retained (Figure 9) (MCanulty et al. 1995; Bacon 2018). The debris and tissue of the bulla should be gently removed with haemostats, alligator forceps, suction, or curette. The epitympanic recess should be avoided, not to damage the round and oval windows (Tobias 2013b), as well as the curettage of the rostralmedial area of the tympanic cavity, to prevent damage the auditory ossicles or inner ear structures (Fossum and Caplan 2013). Finally, the bulla and surgical wound must be flushed with a warm saline solution, followed by suction of the residual fluid (Tobias 2013b). Deeper tissues are closed with absorbable interrupted sutures, avoiding the inclusion of the facial nerve (Tobias 2013b), the skin is then closed in a T-shaped configuration and a drain may be placed if there is local infection (Bacon 2018).

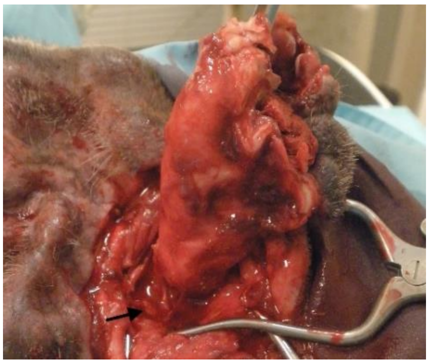


Figure 8 - The facial nerve (arrow) can be seen rostroventrally to the ear canal during TECA-LBO (Image provided by Professor Lisa Mestrinho).

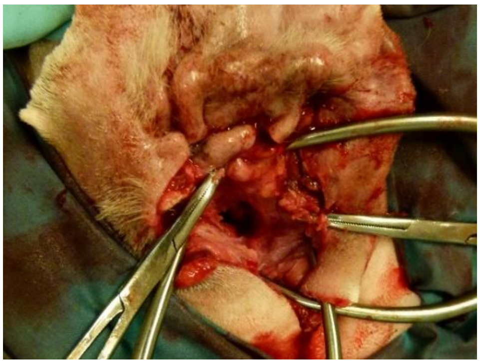


Figure 9 - Opening of the tympanic bulla visible once the tissue is removed by curettage during TECA-LBO (Image provided by Professor Lisa Mestrinho).

6.4.3 Preoperative care and Postoperative care

Many dogs undergoing TECA-LBO have associated skin disease that should be treated before surgery, which benefits the ears as well (Fossum and Caplan 2013). Prophylactic intravenous antibiotic should be initiated just before surgery with amoxicillin-clavulanate or aminoglycosides, since about 90% of isolates from TECA surgeries are susceptible to this antibiotics (Vogel et al. 1999; Smeak 2013). TECA-LBO is very painful and the best analgesic premedicants used for this kind of surgeries are hydromorphone and morphine. Bupivacaine hydrochloride can also provide local analgesia for 4 to 6 hours in conjunction with other analgesics. In dogs, protocols including fentanyl, lidocaine, ketamine (FLK) or morphine, lidocaine, ketamine (MLK) in constant rate infusion (CRI) may be used intraoperatively or postoperatively (Fossum and Caplan 2013). In the first 24 hours after surgery a loosely stockinette holding sponges on the wound is the preferred option, however head-encircling bandages may be used instead (Lanz & Wood 2004; Smeak 2013). Postoperatively, the same premedicant analgesics should be readministered to manage pain and if the animal appears dysphoric or anxious benzodiazepines can be used to control it (Fossum and Caplan 2013). Elizabethan collars are also helpful until sutures are removed in 10 to 14 days. The antibiotic therapy is adjusted according to the culture and antibiotic sensitivity testing of the material collected from the bulla (Petersen et al. 2002; Smeak 2013), during 7 to 10 days. Facial nerve function has to be evaluated and if deficits are seen, eye lubricants are applied to reduce corneal ulcers after surgery (Smeak 2013). In addition, lidocaine patches can be placed over the surgical incision site for the first 12 hours. After this time, oral analgesics are recommended for 5 to 7 days after surgery (Tranquilli et al. 2004; Smeak 2013).

7. Complications of TECA-LBO surgery

Many complications of TECA-BLO surgery have been documented in the veterinary literature and its rates variety from 29% to 82% (Smeak and DeHoff 1986; Mason et al. 1988; Beckman et al. 1990; Matthiesen and Scavelli 1990; White and Pomeroy 1990; Bacon et al. 2003; Spivack et al. 2013). Despite the potential for morbidity, TECA-LBO is highly effective in eradicating ear disease, providing pain relief, and treating advanced otitis (Spivack et al. 2013).

Intraoperative complications such as major haemorrhage during ear canal ablation is rare, with reported incidence of 3% to 14% (White and Pomeroy 1990; Guillaumot et al. 2011; Bacon 2018). It is usually caused by damage to the retroglenoid vein and may threat the dog's life (Mason et al. 1988; Smeak et al. 1996; Bacon 2018). There are other sources of significant haemorrhage, including, the external carotid artery, the maxillary vein, and the internal carotid artery (Smeak 2011). Another intraoperative complication may be the accidently transection of the facial nerve during deep dissection of the horizontal ear canal, though this is a less frequent situation, happening only in 4% to 6% of the surgeries (Smeak and DeHoff 1986; Mason et al. 1988; Matthieson and Scavelli 1990; Smeak 2011). To avoid cutting the nerve, it should be isolated and protected as early as possible during the procedure (Smeak 2011).

During surgery, debris and contaminated exudate within the ear canal usually spill into the deep wound, so if the wound becomes infected some complications such as acute cellulitis/ abscessation, incisional hematoma, incisional dehiscence, and extended wound drainage may develop in 8% to 31% of the cases (Smeak and DeHoff 1986; Mason et al. 1988; Matthieson and Scavelli 1990; White and Pomeroy 1990; Smeak 2011). To fight these complications, the wound must be drained due to the dead space left and high contamination, and also be treated with appropriate antibiotic until second intention healing occurs (Smeak and DeHoff 1986; Mason et al. 1988; Matthieson and Scavelli 1990; Smeak and Kerpsack 1993; Smeak et al. 1996; Smeak 2011). Wound dehiscence is common after ear surgery and often secondary to poor apposition of the layers, integumentary inflammation, delayed healing, self-inflicted trauma, or failure to appreciate wound healing factors. Wound dehiscence is seen in up to 25% of TECA cases, but most do not require surgical revision (Guillaumot et al. 2011; Bacon 2018).

The facial nerve can be damaged during ear canal ablation due to its close association with the horizontal canal (Miller et al. 1964; Smeak and DeHoff 1986) or also suffer injury during exposure of the osseous bulla and debridement of its contents (Devitt et al. 1997). Facial nerve paralysis is a common complication occurring in 13% to 36% of the cases (Smeak and DeHoff 1986; Mason et al. 1988; Matthieson and Scavelli 1990; White and Pomeroy 1990; Devitt et al. 1997; Smeak 2011). It is characterised mostly by palpebral reflex deficit and ipsilateral drooping of the facial expression muscles (ear and lip). The facial nerve deficits can be temporary or permanent (Doyle et al. 2004). Other clinical signs reported are widened palpebral fissure, drooling, absence of spontaneous and provoked blinking that may result in corneal ulceration, absence of nostril abduction during inspiration, deviation of the nostril and facial spasms. If the affected portion of the facial nerve is between the medulla and the middle ear, dysfunction of the parasympathetic supply of the lacrimal gland will lead to neurogenic keratoconjunctivitis sicca (Figure 10), potentially causing recurrent corneal ulceration, mucous ocular discharge, conjunctival hyperemia or chronic keratitis (Dewey and Cerda-Gonzalez 2008; Garosi et al. 2012; Calvo et al. 2014).

Horner's syndrome or oculo-sympathetic paralysis is caused by iatrogenic disruption of the sympathetic nerve fibres that distribute over the bony promontory of the middle ear (Evans and Christensen 1979; Slatter 2003; Spivack et al. 2013). In dogs, Horner's syndrome is rarely seen after TECA-LBO surgery but small rates between 3.3% and 7.5% were reported (Spivack et al. 2013; Coleman and Smeak 2016). The clinical signs observed are miosis, ptosis, enophthalmos, partial protrusion of the third eyelid and anisocoria (Taylor 2014).

Hypoglossal nerve dysfunction is associated with an excessive ventral dissection of the tympanic bulla (Mason et al. 1988; Sharp 1990; Lanz and Wood 2004). This complication has only been reported in dogs and occurs rarely in the early postoperative period (Ter Haar 2016) in less than 8% of the surgeries. Some clinical signs of this condition are excessive drooling and dysphagia (Mason et al. 1988; Sharp 1990; Smeak 2011).

Vestibular signs and head tilt caused by inner ear damage occur after TECA-LBO in 3% to 8% of the dogs (Smeak and DeHoff 1986; Mason et al. 1988; Beckman et al. 1990; Matthieson and Scavelli 1990; White and Pomeroy 1990; Devitt et al. 1997; Doyle et al. 2004; Mathews et al. 2006; Smeak 2011). Peripheral vestibular ataxia (Figure 11) and hearing loss may also be caused by inner ear damage, that occurs due to injury of the round or oval window during removal of tissue from the epitympanic recess and promontory areas (Ter Haar 2016).

Pinna necrosis occurs due to damage to the pinna vasculature during medial dissection of the vertical ear canal and it is often found along the caudal margin of the pinna (Smeak and DeHoff 1986; Smeak 2011). This complication is treated by debridement of devitalized tissue, and the open wound heals for second intention. During the detachment of the ear canal, damage to the blood supply of the pinna should be avoided (Smeak 2011).

Significant pharyngeal swelling can occur if TECA-LBO is preformed bilaterally and in dogs with pre-existing airway obstruction (bulldogs). Head-circling bandages can also constrict the pharynx and cause suffocation after surgery (Smeak and Kerpsack 1993; Smeak 2011).

Chronic dermatitis of the pinna is detected in up to 21% of dogs after surgery. This complication results from progression of a dermatologic disease and/or incomplete removal of proliferative tissue at the base of the pinna. Despite removal of the entire ear canal, dermatitis cause persistent head shaking and self-mutilation (Smeak and Kerpsack 1993; Smeak 2011).

The most concerning long-term complication found after TECA-LBO involves recurrent otitis media (Smeak and Kerpsack 1993; Hardie et al. 2008; Smeak 2011). This complication causes pain upon opening the mouth, diffuse swelling, and when the infection becomes fulminate, draining tracts develop. The most common underlying reason for recurrent infection is incomplete removal of the infected epithelium of the tympanic bulla or osseous ear canal (Beckman et al. 1990; White and Pomeroy 1990; Smeak et al. 1996; Holt et al. 1996; Hardie et al. 2008; Smeak 2011). Recurrent deep infection usually requires surgical exploration (Smeak et al. 1996; Hardie et al. 2008; Smeak 2011). Deep infection can be manifested as chronic or recurrent fistulation adjacent to the TECA site, or abscessation deep to the subcutaneous tissue (Smeak and DeHoff 1986; Mason et al. 1988; Beckman et al. 1990; Matthiesen and Scavelli 1990; Sharp 1990; Holt et al. 1996; Smeak et al. 1996; Smeak 2016).

Hearing loss may be partial or complete in cases of otitis media even before surgery due to impaction of exudate in the external or middle ear, ear canal stenosis, tympanic membrane rupture, damaged of the auditory ossicles or foreign bodies (Steiss et al. 1992; Strain 1996; Eger and Lindsay 1997; Strain 2011; Mason et al. 2013). When bilateral TECA-LBO is performed, the dog is, for all practical purposes, deaf after surgery. However detection of vibration or motions may call the attention of the animal and create the appearance of hearing (Krahwinkel et al. 1993; MCanulty et al. 1995). After one experimental TECA-LBO study where the tympanic membrane and ossicles were purposely removed, 100% of normal dogs were deaf after surgery as determined by electronic measurements of air-conducted brain stem auditory evoked potentials (MCanulty et al. 1995; Smeak 2011). The dogs that retained some hearing were the ones that had remains of tympanic membrane and ossicles (Payne et al. 1989; Krahwinkel et al. 1993; Smeak 2011).

The appearance of upright ear dogs may change after TECA-LBO once the ears may fail to stand due to loss of support to the base of the pinna, especially if the ear canal excision is extended well up into the base of the pinna (Teer Haar 2016). A new technique of sub-total ear canal ablation may be used to maintain erect ear carriage, preserving the distal portion of the vertical canal, when the disease is limited to the horizontal ear canal (Charlesworth 2012), and without ceasing to remove all the infected tissue (Mathews et al. 2006; Smeak 2011).

Figure 10 - Dog with facial nerve paralysis due to middle ear disease showing a dry crusted nose and keratoconjunctivitis sicca (Adapted from Tobias 2013b with permission).

Figure 11 - Cocker Spaniel with left peripheral vestibular disease caused by otitis media (Adapted from Taylor 2014 with permission).

Chapter III - Complications and surgical outcome in dogs with otitis media undergoing total ear canal ablation and lateral bulla osteotomy: a retrospective study of 37 cases

1. Objectives

The aim of this study was to evaluate the association between postoperative complications of TECA-LBO surgery and variables such as age, breed, sex, bacterial infection and surgical outcome. Despite the limitations inherent to a retrospective clinical study it was made an attempt to evaluate, classify and describe the surgical complications and outcome.

2. Materials and Methods

2.1 Criteria of inclusion

The animals included in this study were diagnosed with chronic otitis externa or otitis media nonresponsive to medical therapy, and therefore had indication for surgical treatment. The dogs were submitted to TECA-LBO surgery, and samples from the tympanic bulla were taken and sent for bacterial culture. This study included 32 animals (37 ears), 32 preformed unilateral TECA-LBO and 5 preformed bilateral TECA-LBO between February 2010 and April 2020. The 37 surgeries were performed in different veterinary clinics or hospitals: Small Animal Hospital of the University of Budapest (15 cases), Veterinary School Hospital of the University of Lisbon (11 cases), Restelo Veterinary Hospital (4 cases), Aniaid (4 cases), Lusófona Veterinary Hospital (2 cases), and VetZoolar (1 case).

2.2 Criteria of exclusion

The animals excluded of the study were the ones who, despite have been submitted to TECA-LBO surgery, did not have the same diagnosis of chronic otitis externa or otitis media nonresponsive to treatment, such as neoplasia, polyps or traumatism.

2.3 Variables

The variables used for this study were: age, sex, breed, bacterial culture results, presence of postsurgical complications, type of complications if present and surgical outcome.

2.4 Procedures

Part of the information was arranged through search of clinical records and also data provided by a previous study (Ferreira 2019).

Due to the retrospective nature of this study, the history, the clinical signs, the diagnostic procedures, the anaesthesia protocol, the surgery technique, the samples taken from the tympanic bulla, and the follow-up of the cases were not described.

All the animals were diagnosed with chronic otitis externa or otitis media and submitted to TECA-LBO surgery. Although the surgical techniques was not described in detail by the different surgeons, the surgical technique is a standard procedure.

In the total ear canal ablation (TECA) it is performed a T-shaped incision, then retraction of skin flaps and dissection of the soft tissues as close as possible to the cartilage. Followed by an incision and dissection around the opening of the vertical ear canal. Finally, the dissection is made at the level of the external acoustic meatus, preforming the amputation of the horizontal ear canal and removal of epithelial tissue.

In the lateral bulla osteotomy (LBO) the dissection of the tissue ventrolateral to the tympanic bulla is made using a periosteal elevator. The removal of the ventrolateral osseous portion of the bulla is also done, so it can be possible to observe and have access to the interior of the tympanic cavity. This way the exudate and infected epithelium are completely removed using a curette. A sample from the tympanic cavity is taken using a sterile swab and is sent for bacterial culture. Then, the tympanic cavity is irrigated with a warm saline solution and closed with an absorbable subcutaneous suture. If necessary, a Penrose drain is placed.

2.5 Classification of Bacterial Infection, Complications and Outcome

In all the cases, samples from the tympanic bulla were taken and submitted for bacterial culture. Although the results of these bacterial cultures are known, in this study they were only classified as positive or negative, ignoring the type of bacteria present.

Some animals had intraoperative and postoperative complications, however only the postoperative complications were considerate for the study. These postsurgical complications were classified in 3 types or categories: neurological complications, abscess or fistulation and suture dehiscence. In the neurological complications were included facial nerve paralysis, Horner’s syndrome, hypoglossal nerve dysfunction, and inner ear damage.

The surgical outcome was also classified in 3 categories: good, satisfactory and poor. Good was attributed to the cases with none or 1 complication; satisfactory was given to those cases with the presence of 2 complications; and poor was attributed to the dogs with the 3 types of complications. Having in mind that these different types of complications do not have the same impact in the animal’s recovery and quality of life.

This evaluation and classification of the TECA-LBO results was based on the criteria used by Mason et al. (1988) and Doyle et al. (2004), where the outcome was classified as: excellent when there was resolution of clinical signs of ear disease without long-term complication; improved when there was improvement of clinical signs after surgery but continued disease of the remaining medial wall of the pinna requiring treatment, or facial nerve paralysis not requiring treatment; and poor when ear canal or middle ear disease remained present, or there was permanent facial nerve paralysis requiring continued medical treatment.

2.6 Statistical analysis

After collecting all the information, it was organized in order to create a data base. The analysis was then preformed using the Microsoft Office Excel 2019® and the IBM SPSS Statistics 22®. The Mann-Whitney U test and the Fisher's exact test were used to evaluate the association between the occurrence of postoperative complications (neurological complications, abscess or fistulation, and suture dehiscence), surgical outcome and variables such as age, sex, breed, and bacterial infection. A 95% confidence interval was used and p values < 0.05 for the level of statistical significance.

3. Results

3.1 Cases characterization

Of the total 37 cases, 13 cases (35.14 %) occurred in females and 24 cases (64.86%) occurred in males, with ages between 2 and 13 years old, with a mean age of 7.89 years old.

The most represented breeds were the French bulldog (5 cases), the German Shepard (3 cases), the Cocker Spaniel (2 cases), the Estrela Mountain Dog (2 cases), the Labrador retriever (2 cases), and the West Highland white terrier (2 cases), the other breeds represented in the study (Bichon Bolognese, Vizla dog, Poodle, Fox terrier, German wirehaired pointer, Briard, Petit Basset Griffon, Pug, Puli, Rottweiler, Shar-pei, Spitz, and Yorkshire terrier) had only 1 case each. The other remaining 8 cases were from mixed breed dogs.

3.2 Postoperative complications and outcome

The bacterial infection results was negative in 5 cases (13.51%) and positive in 32 cases (86.49%).

Postoperative complications were present in 20 cases (54.05%), the other 17 cases (45.95%) did not present any type of complications. Neurological complications were present in 13 cases (35.14%), abscess or fistulation occurred in 7 cases (18.92%), and suture dehiscence happened in 8 cases (21.62%).

The surgical outcome was good in 31 cases (83.78%), satisfactory in 4 cases (10.81%), and poor in only 2 cases (5.41%). The results are summarized in Table 1.

The majority of the dogs had a good surgical outcome, which means most dogs had a good prognosis and the surgery was effective in the resolution of the otitis media.

Table 1 - Number and percentage of cases of bacterial infection, complications and type of complications according to outcome.

Variables		Surgical Outcome		
		Good	Satisfactory	Poor
Bacterial Infection	Negative	5 (13.51%)	0	0
	Positive	26 (70.27%)	4 (10.81%)	2 (5.41%)
Complications	No	17 (45.95%)	0	0
	Yes	14 (37.84%)	4 (10.81%)	2 (5.41%)
Neurological Complications	No	22 (59.46%)	2 (5.41%)	0
	Yes	9 (24.32%)	2 (5.41%)	2 (5.41%)
Abscess/ Fistulation	No	28 (75.68%)	2 (5.41%)	0
	Yes	3 (8.11%)	2 (5.41%)	2 (5.41%)
Suture dehiscence	No	29 (78.38%)	0	0
	Yes	2 (5.41%)	4 (10.81%)	2 (5.41%)

3.3 Association between complications and age, sex, breed and bacterial infection

Table 2 summarizes the results obtained. No significant associations were found between the variables age, sex, breed, bacterial infection and postoperative complications.

Table 2 - Number and percentage of cases of postoperative complications according to age, sex, breed and bacterial infection.

Variables		Postoperative complications			p-value
		No	Yes	Total	
Age (Mean and Range)		7.82 (2 - 13)	7.95 (3 - 13)	---	0.866*
Sex	Female	7 (18.92%)	6 (16.22%)	13 (35.14%)	0.512⁺
	Male	10 (27.03%)	14 (37.84%)	24 (64.86%)	
Breed	Mixed breed	5 (13.51%)	3 (8.11%)	8 (21.62%)	0.191⁺
	French Bulldog	1 (2.70%)	4 (10.81%)	5 (13.51%)	
	German Shepherd	0	3 (8.11%)	3 (8.11%)	
	Cocker Spaniel	1 (2.70%)	1 (2.70%)	2 (5.41%)	
	Labrador retriever	1 (2.70%)	1 (2.70%)	2 (5.41%)	
	Estrela mountain dog	2 (5.41%)	0	2 (5.41%)	
	West highland white terrier	0	2 (5.41%)	2 (5.41%)	
Bacterial Infection	Negative	2 (5.41%)	3 (8.11%)	5 (13.51%)	1⁺
	Positive	15 (40.54%)	17 (45.95%)	32 (86.49%)	

*Mann-Whitney value; ⁺Fisher's exact value

3.4 Association between outcome and age, sex, breed and bacterial infection

Table 3 summarizes the associations between outcome and the variables age, sex, breed and bacterial infection, which were non-significant.

Table 3 - Number and percentage of cases of surgical outcome according to age, sex, breed and bacterial infection.

Variables		Surgical Outcome				p-value
		Good	Satisfactory	Poor	Total	
Age (Mean and Range)		7.83 (2 - 13)		9 (9 - 9)	---	0.839*
Sex	Female	11 (29.73%)	2 (5.41%)	0	13 (35.14%)	0.502^{+}
	Male	20 (54.05%)	2 (5.41%)	2 (5.41%)	24 (64.86%)	
Breed	French Bulldog	4 (10.81%)	1 (2.70%)	0	5 (13.51%)	0.388^{+}
	Cocker Spaniel	2 (5.41%)	0	0	2 (5.41%)	
	Labrador retriever	2 (5.41%)	0	0	2 (5.41%)	
	German Shepherd	3 (8.11%)	0	0	3 (8.11%)	
	Estrela mountain dog	2 (5.41%)	0	0	2 (5.41%)	
	Mixed breed	7 (18.92%)	1 (2.70%)	0	8 (21.62%)	
	West highland white terrier	1 (2.70%)	0	1 (2.70%)	2 (5.41%)	
Bacterial Infection	Negative	5 (13.51%)	0	0	5 (13.51%)	1^{+}
	Positive	26 (70.27%)	4 (10.81%)	2 (5.41%)	32 (86.49%)	

***Mann-Whitney value; $^{+}$Fisher's exact value**

3.5 Association between complications and outcome

The occurrence of complications were significantly different between good, satisfactory and poor outcomes (p = 0.035) (Table 4).

In the presence of postoperative complications there are more probabilities of having a satisfactory or poor outcome, and less probability of having a good outcome.

Table 4 - Estimated probability of complications and surgical outcome.

Complications	Surgical Outcome: Good	Satisfactory	Poor	Total	Fisher's exact test p-value
No	17 (45.95%)	0	0	17 (45.95%)	0.035
Yes	14 (37.84%)	4 (10.81%)	2 (5.41%)	20 (54.05%)	
Total	31 (83.78%)	4 (10.81%)	2 (5.41%)	37 (100%)	

3.5.1 Association between outcome and neurological complications

Neurological complications were not significantly associated with the surgical outcome (p = 0.077) (Table 5).

3.5.2 Association between outcome and abscess or fistulation

The occurrence of abscess or fistulation was significantly associated with the surgical outcome (p = 0.003) (Table 5 and Chart 1).

3.5.3 Association between outcome and suture dehiscence

There is an association between the occurrence of suture dehiscence and the surgical outcome (p < 0,001) (Table 5 and Chart 2).

Table 5 - Number and percentage of neurological complications, abscess or fistulation, and suture dehiscence according to the outcome.

Variables		Surgical Outcome: Good	Satisfactory	Poor	Total	Fisher's exact test p-value
Neurological Complications	No	22 (59.46%)	2 (5.41%)	0	24 (64.86%)	0.077
	Yes	9 (24.32%)	2 (5.41%)	2 (5.41%)	13 (35.14%)	
Abscess/ Fistulation	No	28 (75.68%)	2 (5.41%)	0	30 (81.08%)	0.003
	Yes	3 (8.11%)	2 (5.41%)	2 (5.41%)	7 (18.92%)	
Suture dehiscence	No	29 (78.38%)	0	0	29 (78.38%)	< 0,001
	Yes	2 (5.41%)	4 (10.81%)	2 (5.41%)	8 (21.62%)	

Chart 1 - Estimated probability of abscess or fistulation occurring according to surgical outcome.

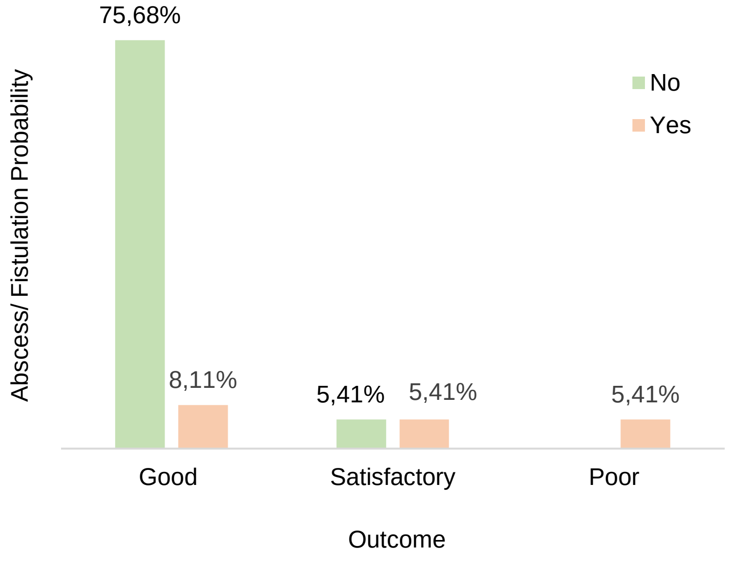
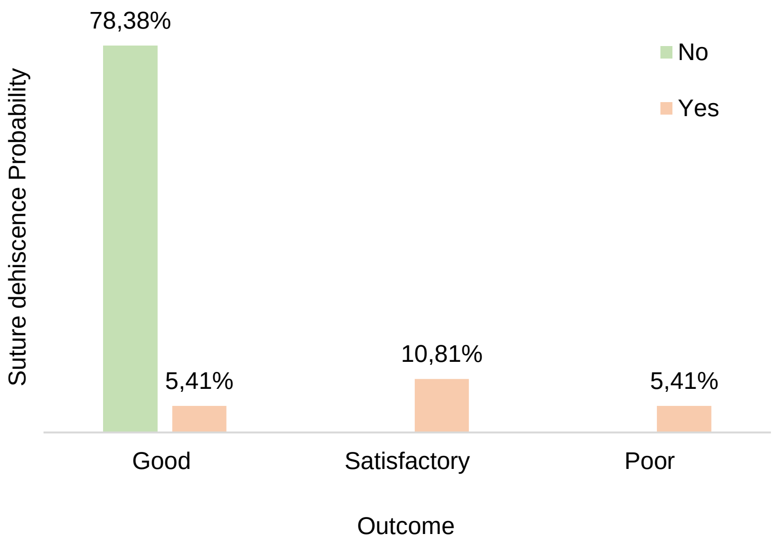


Chart 2 - Estimated probability of suture dehiscence occurring according to surgical outcome.



4. Discussion

For the interpretation of these results it is important to have in consideration the limitations of the study. The main limitations are due to its retrospective nature, with little information or not enough detailed information to collect data regarding the occurrence of complications. Sample limitation was another issue that resulted from the inclusion criteria, although a reduced sample is expected, since this is a treatment of last resort.

In this study the animals that underwent surgery had ages between 2 and 13 years old, with a mean age of 7.89 years old. This mean and range of ages are similar to the ones observed in the previous studies of Doyle et al. (2004), Hettlich et al. (2005), Guillaumot et al. (2011), Spivack et al. (2013), and Coleman and Smeak (2016).

It was not possible to find any association between the age of the dogs and the occurrence of postoperative complications or with the surgical outcome. The mean of ages found in the dogs that had complications (7.82 years old) was very similar to the one found in the dogs that had no complications (7.95 years old). The mean of ages was also similar in the dogs with good or satisfactory outcome (7.83 years old), and in the dogs with poor outcome (9 years), which supports as well the fact that age does not influence the surgical outcome. In the study of Spivack et al. (2013) age was not a significant risk factor in the development of residual facial nerve injury, one of the neurological complications often found after this surgery. This finding corroborates the results of the present study where no association was found between age and the occurrence of complications, including the neurological ones. Older animals would potentially be more susceptible to complications due to the increased risk of comorbidities, however this was not observed here. Regardless, it is known that the age of the animal may be somehow related to the severity of the otitis media. Since otitis media usually occurs as an extension of otitis externa, and it most frequently affects middle-aged or older dogs. Sporadically, it may affect younger dogs (Paterson 2020). Zur et al. (2011) concluded that otitis is more severe when it is first diagnosed in older dogs, and that all the dogs with more than 5 years old had presence of microorganisms at significantly higher levels, which may be explained by chronic alterations within the ear canal and the possibility that otitis media was not diagnosed when these dogs were younger. Additionally, the severity of the otitis may be influenced by the age at onset. This might explain a possibly more severe otitis due to endocrinopathies, which are typically diagnosed in older dogs, and a less severe otitis in allergies, which are commonly diagnosed in younger dogs.

In this study 13 cases occurred in females (35.14%) and 24 in males (64.86%). This percentage of males and females was similar to those observed in the studies of Doyle et al. (2004), Hettlich et al. (2005), Guillaumot et al. (2011), and Coleman and Smeak (2016), where males constituted the majority of the cases, around more than 50% to 65%, approximately. Additionally, the sex of the animals had no significant effect on the risk of developing ear disease that could progress to end-stage otitis in a study (Mason et al. 1988). The results obtained here could just be due to chance consequent to the limited number of cases. It was not found any associated between sex and the occurrence of postoperative complications or with the surgical outcome.

Another of the variables evaluated in this study was the breed of the dogs. The most represented breeds were the French bulldog with 5 cases, the German shepherd with 3 cases, the Cocker Spaniel, the Estrela Mountain Dog, the Labrador retriever, and the West Highland white terrier with 2 cases each. French bulldogs, German Shepherds, Cocker Spaniels, Labrador retrievers, West Highland White terriers, Shar-peis, Poodles, Yorkshires, and Pugs were breeds also well represented in the previous studies of Doyle et al. (2004), Hettlich et al. (2005), Guillaumot et al. (2011), Spivack et al. (2013), and Coleman and Smeak (2016). There are certain breeds with more predisposition to otitis externa, and therefore with a special predisposition to develop otitis media as well. This racial predisposition to otitis is mostly due to the dogs' ear type, ear canal conformation or breed associated diseases. However, this breed predisposition is not associated with the occurrence of postoperative complications in TECA-LBO, therefore, as expected, breed was not associated with the occurrence of postoperative complications or the surgical outcome.

Nevertheless, in French bulldogs, one of the most represented breeds in this study (5 cases), were registered 4 postoperative complications. In this case series 1 French bulldog presented abscess or fistulation and suture dehiscence, having a satisfactory outcome. The other 3 French bulldogs had only neurological complications and ended with a good outcome. These findings may suggest that brachycephalic dogs have a greater predisposition to develop complications, what can be explained by their abnormal tympanic bulla conformation that creates more technical difficulties for good surgical performance. Tympanic bulla malformation and Eustachian tube dysfunction were identified in brachycephalic breeds, namely French bulldogs in the previous studies of Owen et al. (2004) and Mielke et al. (2017). In the study of Salgüero et al. (2016), dogs affected with brachycephalic obstructed airway syndrome, in particular French bulldogs, English bulldogs, and Pugs had thicker tympanic bulla wall with a thicker rostro-ventral aspect and thinner caudo-ventral aspect, compared to non-brachycephalic dogs. These abnormal and narrow anatomic conditions in brachycephalic dogs possibly predispose such breeds to develop complications such as cholesteatoma after middle ear surgery because complete removal of all inflammatory and epithelial tissue can be more difficult than in other breeds (Schuenemann and Oechtering 2012). The same study suggested that in TECA-LBO surgery in brachycephalic dogs, due to their anatomic circumstances, was more difficult to achieve a good exposure of the bulla and consequently the complete removal of all modified tissue can be very difficult to achieved. In cases where anatomic malformation is already observed on CT scans preoperatively, a more aggressive approach of the surgery should be considered or even may be indicated to perform a ventral bulla osteotomy (Smeak et al. 1994; Schuenemann and Oechtering 2012).

In this study, bacteriological culture of the tympanic bulla was positive in 32 cases (86.49%) and negative in 5 cases (13.51%). These results are similar to the one found in the study of Spivack et al. (2013), however the negative culture results are slightly higher than the ones found in the studies of Guillaumot et al. (2011), and Coleman and Smeak (2016). These findings support that in the great majority of the cases a positive bacterial culture is present in dogs with otitis media undergoing TECA-LBO. However, the absence of bacterial growth in some cases maybe due to non-septic inflammation of the middle ear or due to surgical lavage of the tympanic cavity before taking the sample, which was demonstrated in the study of Hettlich et al. (2005) where the number of bacterial isolates per ear before flushing was superior to the number of isolates found in samples taken after flushing.

In the present study it was not found any association between the bacterial infection and the occurrence of complications, or the outcome of the surgery. These results may be explained by the effectiveness of antibiotic therapy based in culture and susceptibility testing and to the effectiveness of the surgical cleaning and debridement. Similar conclusions were also reported by another study (Coleman and Smeak 2016).

In this study, postoperative complications were high, 20 out of 37 cases (54.05%). The complication values found in this study were within the range of previously reported case series rates that were between 21% and 82% (Smeak and DeHoff 1986; Mason et al. 1988; Beckman et al. 1990; Matthiesen and Scavelli 1990; Sharp 1990; White and Pomeroy 1990; Devitt et al. 1997; Doyle et al. 2004; Mathews et al. 2006; Hardie et al. 2008; Coleman and Smeak 2016). Additionally, the surgical outcome was good in 31 cases (83.78%), satisfactory in 4 cases (10.81%), and poor in only 2 cases (5.41%). Again, similar to previous reports of favourable outcome in 76% to 95% of dogs (Mason et al. 1988; Beckman et al. 1990; White and Pomeroy 1990; Matthieson and Scavelli 1990; Doyle et al. 2004). This high complication rate associated with TECA-LBO is expected since is it a procedure performed in the advanced stage of the disease, with deep and persistent infection, in a surgically difficult anatomical area with close proximity with delicate and vital structures. Therefore there is a high risk of complications associated with advanced stage of illness and iatrogenic lesions.

It was found an association between the postoperative complications and the surgical outcome. In the presence of complications, there are more chances to have a poor outcome. The higher probability to have complications found in the cases with good outcome resulted from the fact that the total number of cases of good outcome, compared with satisfactory and poor was superior. On the other hand, a good outcome can be achieved because most complications related to the TECA-LBO procedure are transitory, minor or self-limiting and resolve within weeks if approached appropriately (Smeak and DeHoff 1986; Matthiesen and

Scavelli T 1990; Smeak and Kerpsack 1993; Coleman and Smeak 2016). However, in this study was not differentiated into major or minor complications. This choice resulted from the fact that the some descriptions of the complications in the clinical documents were not clear to allow such classification for all cases.

Neurological complications were present in 13 cases (35.14%) in this study, which is within the range of 13% and 58% reported in previous studies (Smeak and DeHoff 1986; Mason et al. 1988; Matthiesen and Scavelli 1990; Sharp 1990; White and Pomeroy 1990; Devitt et al. 1997; Wolfe et al. 2006; Spivack et al. 2013; Coleman and Smeak 2016). Facial nerve paralysis, both temporary and permanent, occurred in between 33% and 40% of the cases as documented in several studies (Smeak and DeHoff 1986; Mason et al. 1988; Matthiesen and Scavelli 1990; Sharp 1990; White and Pomeroy 1990; Devitt et al. 1997; Wolfe et al. 2006; Spivack et al. 2013; Coleman and Smeak 2016). Vestibular signs, including head tilt, nystagmus, or circling, occurred temporarily in between 2% and 23% of the cases, according to previous studies (Spivack et al. 2013; Coleman and Smeak 2016). In dogs, Horner’s syndrome is rarely seen after TECA-LBO surgery but small rates between 3.3% and 7.5% were reported in 2 recent studies (Spivack et al. 2013; Coleman and Smeak 2016). Again, the type of neurological complications such as facial nerve paralysis, Horner’s syndrome, hypoglossal nerve dysfunction, and other complications associated with inner ear damage were not detailed in this study since there was lack of information about the type of lesion in some cases. Regardless, no association was found between the occurrence of neurological complications and the surgical outcome. Observing the results, the occurrence of neurological complications did not have an influence in the outcome, because 9 of the cases that had this type of complications manage to have as well a good outcome, which may be explained by the transitory character of this type of complications.

In this study abscess or fistulation occurred in 7 cases (18.92%). This rate was a little higher than the one found in previous reports (2% to 14%) (Smeak and DeHoff 1986; Mason et al. 1988; Beckman et al. 1990; Matthiesen and Scavelli 1990; Sharp 1990; Holt et al. 1996; Smeak et al. 1996; Smeak 2016).

This study revealed there is an association between the occurrence of abscess or fistulation and the surgical outcome. The animals with a poor surgical outcome are associated with the presence of abscess or fistulation. The influence of infection manifested as chronic and recurrent fistulation or abscessation in the surgical outcome is due to the fact that this type of complication may appear several years after TECA-LBO surgery was performed, and therefore compromise the animal’s quality of life (Holt et al. 1996; Smeak et al. 1996; Spivack et al. 2013; Smeak 2011; Smeak 2016).

In this study suture dehiscence was registered in 8 cases (21.62%), which is within the rates of 15.7% and 41% observed in earlier reports (Smeak and DeHoff 1986; Mason et al.

1988; Matthiesen and Scavelli 1990; White and Pomeroy 1990; Spivack et al. 2013). It was found an association between the occurrence of suture dehiscence and the surgical outcome. More precisely, it was found an association between the suture dehiscence and a better surgical outcome, showing that this type of complication, if managed correctly, does not have a negative influence in the final outcome. Rates of incisional complications such as suture dehiscence have recently decreased a lot compared to the previous rates documented. This reduction may be due to thorough curettage of the bulla to remove the epithelial lining (White and Pomeroy 1990; Spivack et al. 2013), however intraoperative placement of drains has not produced superior results over meticulous primary closure (Devitt et al. 1997; Spivack et al. 2013). Regardless, the actual rate of abscess or fistulation occurrence may be higher than the recorded because many retrospective studies do not document long-term follow-up (more than 1 year) (Holt et al. 1996; Smeak et al. 1996; Spivack et al. 2013; Smeak 2011; Smeak 2016). The risk of deep infection, and therefore of a poor outcome, increases dramatically (up to 53%) when TECA-LBO is performed in dogs with end-stage ear disease and middle ear cholesteatomas because this expansile middle ear epithelial cyst is extremely challenging to completely excise (Hardie et al. 2008; Smeak 2016). These observations could not be appreciated in the present case series due to the limited number of cases and limited post operatory follow up for some of the cases.

In terms of prognosis, although postoperative complications were present in 20 cases (54.05%), the surgical outcome was good in 31 cases (83.78%), suggesting that the surgery was effective in the definitive resolution of the otitis media.

Future studies, including more cases will be needed to better know the postoperative complications associated with TECA-LBO. Therefore, it would be interesting to standardize the registration of complications. With regards to facial nerve paralysis, the Schirmer tear test could also be done before and after surgery to verify the lacrimal production, and control the existence of facial nerve paralysis in all the dogs. Long term follow up of years would also be necessary to fully evaluate the success rate of this technique.

5. Conclusion

TECA-LBO is technically efficient to resolve chronic otitis media in dogs although it is associated with an important complication rate, namely dehiscence and fistulation which is significantly associated with failure.

Bacterial infection was present in almost every case, and postoperative complications occurred in more than half of the cases. The most frequent type of complications were the neurological ones, followed by suture dehiscence and abscess or fistulation.

No associations were found between the occurrence of complications, outcome and clinical variables such as the dog's age, sex, breed or presence of bacterial infection.

It was found an association between postoperative complications and a poor surgical outcome, in particular with the presence of abscess or fistulation. On the other hand, it was found an association between the suture dehiscence and a better surgical outcome. No association was found between the occurrence of neurological complications and the surgical outcome.

Regardless of the high rate of complications found, the great majority of the cases presented a good outcome, corroborating the fact that TECA-LBO remains an effective surgical technique to treat dogs with chronic otitis externa or otitis media non responsive to medical treatment.

Future studies with a high number of cases need to be done in order to better know the postoperative complications associated with TECA-LBO. In the same way, to fully evaluate the success rate of this technique, it would be necessary a long term follow up of years.

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