

Ear Surgery in Pet Rabbits

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ABSTRACT

Otitis in pet rabbits can be difficult to diagnose due to a number of unique features of anatomy and pathophysiology; and because clinical symptoms can be subtle. A number of surgical techniques have been reported, and vary depending on the type and location of the disease: lateral ear canal resection (LECR) with different variations; total ear canal ablation (TECA); lateral ostotomy or partial ear canal resection (PECR); osteotomy of the tympanic bulla with lateral (LBO) or ventral (VBO) approach. Surgery of the ear pinna includes partial amputation, and surgical treatment of otohematomas.

ANATOMY OF THE EAR

Like in other mammal species, the ear system in rabbits is a sensory and neurologic organ. It is anatomically divided in three portions: the external ear, the middle ear, and the inner ear (including the vestibular system).

External Ear

The external ear includes the ear pinna, the ear canal, and the tympanic membrane.

The ear pinnae represent a large portion of the body surface in rabbits, and have high vascular support.¹ Ear functions are perception of noise with specific regard to escape from predators, and thermoregulation.¹ However, size of the ear pinna is significantly different in various breeds of pet rabbits. True dwarf rabbits weighing 1 kg or less have typical short and more round ear pinnae.

The ear canal is composed by the cartilaginous acoustic duct and the external acoustic meatus² (which is a short portion of the bony acoustic duct). Since most of the ear canal is cartilaginous, the ear canal may commonly be considered as the cartilaginous acoustic duct only.

The vascular support of the ear pinna is provided by the auricular artery which is visible as a median vessel both on the dorsal and the inner aspect of the pinna.²

The auricular artery originates from the rostral and caudal auricular arteries, which are branches of the external carotid artery.²

There are arteriovenous shunts at the apical portion of the ear pinna, between the auricular artery and the auricular veins.¹ There are three auricular veins, all merging in the maxillary vein, and then in the external jugular vein.² The rostral and the caudal auricular veins run along the margins of the ear pinna, and are also commonly known as marginal veins. The intermedial branch of the caudal auricular vein² runs along the auricular artery, or slightly separated and parallel to the artery. All those vessels may not be clearly visible in standard dwarf rabbits, and individual differences may also be present.

The main cartilage of the pinna is simply named cartilage of auricle.² It has an external convex surface covered by normal skin with rare fur, and an internal concave surface covered by modified skin with no fur. The concave surface is named scapha.²

The proximal part of the margins of the cartilage of the pinna is the helix. Both helices are highly convex/concave, and represent part of the walls of the ear canal.

Most of the lateral wall of the cartilaginous acoustic duct is represented by the tragus. This is a complex cartilaginous plate with a ventromedial part (antitragus) forming the dead end diverticulum of the ear canal, and a proximal appendix (the scutiform cartilage) which is an important point of insertion for auricular muscles. The intertragic incisure is present between the tragus and the antitragus. The dorsal and ventral lateral margins of the tragus are joint with the free margins of the dorsal and the ventral helices. A pretragic incisure is reported between the tragus and the dorsal helix.² In summary, the longest part of the cartilaginous acoustic duct is outlined by the proximal portion of the scapha medially, by the dorsal helix dorsolaterally, by the ventral helix ventrolaterally, and by the tragus laterally.

The cartilaginous acoustic duct is completed by the cartilage of acoustic meatus (CAM), an anular cartilage forming a ring (or short cylinder). The ring is incomplete because of the presence of the cartilaginous incisure of acoustic meatus. This cartilage represents the most proximal cartilaginous portion of the ear canal, and its junction with the external acoustic meatus.

The ear canal includes a short tract within the petrous part of the temporal bone.² This tract is the external bony acoustic duct (or meatus).

The tympanic membrane is located a few millimeters within the bony acoustic duct. It represents the separation between the external ear and the middle ear, and the separation between the external bony acoustic duct and the proximal portion of the bony acoustic duct, beyond the tympanic membrane, which is part of the middle ear.

The whole ear canal is covered by modified skin rich of sebaceous gland normally producing white waxy secretion. Unlike selected carnivore species, standard rabbits of any size including dwarfs do not have the horizontal portion of the ear canal.³ The ear canal is vertical and straight from the distal (external) opening to the tympanic membrane. However, lop-eared breeds (dwarfs and non) have genetic anatomic variations of the ear canal. There is a flexion point at the level of the tragus and/or at the junction between the proximal end of the tragus and the cartilage of acoustic meatus. This flexion actually creates a distal vertical portion and a proximal horizontal portion of the ear canal, giving the peculiar aspect of bent down ear pinnae.⁴

The horizontal portion of the ear canal in lop rabbits includes the very proximal part of the tragus, the cartilage of the acoustic meatus, and external bony acoustic duct. Also, the ear canal is generally narrower than the ear canal of standard rabbits. In many cases, it is narrower than the ear canal of smaller standard rabbits.

Crossbred standard/lop rabbits may have intermediate anatomic changes of the ear canal; or show standard anatomy of a single ear canal, and modified anatomy of the contralateral ear canal. These anatomic differences predispose lop rabbits to accumulation of waxy debris along the whole ear canal, in particular at the flexion point. The different junction between cartilage may also predispose for ectasia of the ear canal at the flexion point. This modified anatomy has a great impact on patterns of ear disease, and related surgical techniques.

Middle and Inner Ear

The middle and the inner ear are located within the petrous bone, which is part of the temporal bone. This bone is commonly named tympanic bulla because it is a cavitory bone with a round shaped ventral aspect. The middle ear includes the bony acoustic duct proximal to the tympanic membrane, and the tympanic bulla.

The rostral and caudal auricular artery originate from the external carotid artery and surround the tympanic bulla ventrally.²

The facial nerve exits the skull through the stylomastoid foramen, and courses rostrally, ventrolaterally to the tympanic bulla.^{2,3}

The inner ear is located on the medial aspect of the petrous bone and of the tympanic bulla, and includes the cochlea and the vestibular system.

PATHOPHYSIOLOGY

Otitis externa, including bacterial and parasitic, has been reported in rabbit.⁴ Purulent otitis externa results in empyema and ectasia of the ear canal (especially in lop rabbits) which is commonly and improperly defined as "ear abscess."⁴

Empyema of the tympanic bulla and/or otitis media can result from otitis externa after rupture of the tympanic membrane, but pathophysiology in the opposite direction can occur as well.^{4,5}

Chronic rhinitis can actually lead to otitis. Rhinitis (including infection or empyema of the maxillary recess) is common in rabbits, but is often subclinical. The rhinopharynx communicates with the middle ear and the tympanic bulla through the Eustachian tubes.^{3,6}

Clinical Signs and Symptoms

Otitis in pet rabbits can be difficult to diagnose due to a number of unique features of anatomy and pathophysiology; and because clinical symptoms can be subtle.

More commonly reported symptoms include head shaking, scratching at the ear, pain on palpation of the ear canal, lethargy, and reduced food intake.^{4,7} However, these may also be mild to absent. Ataxia, head tilt, nystagmus are symptoms related to vestibular syndrome as a result of otitis media or interna.⁷ Other clinical signs include collection of purulent exudate within the ear canal, thickening or swelling at the base of the ear canal, or larger swellings located in the periauricular area.⁸

Diagnosis

A number of tests aid diagnosis. In cases of otitis externa, cytology helps differentiate cerumen vs. purulent debris.³ Culture and sensitivity help identify specific bacterial pathogens. Otoscopy is an excellent tool to identify abnormalities of the external ear canal, but it is often not helpful due to stenosis of the external ear canal.^{3,4}

Otitis media may produce bony abnormalities of the tympanic bulla identified radiographically.^{3,9} Radiographic views include VD and oblique projections, and require near perfect positioning and excellent technique.^{3,9} Early or mild cases usually may not produce detectable radiographic abnormalities. Computed tomography is the best diagnostic imaging modality for identification of specific lesions such as filling of the tympanic bulla, and osteolysis. Both axial and 3D reconstruction views are useful for this purpose.^{3,9}

Medical Treatment

Medical therapy has been reported as poorly effective (especially in case of otitis media that cannot be treated topically),³ and in the author's experience it is unrewarding in all but the mildest cases. Pus in rabbits is thick and difficult to remove, and many cases of otitis media involve empyema of the tympanic bulla and osteolysis, both of which are unlikely to resolve without surgical intervention. Medical therapy may involve long-term antibiotics, ideally chosen with the aid of culture and sensitivity, and flushing of the external ear canal under sedation or general anesthesia in case of otitis externa.³ Analgesic therapy is an adjunct to antibiotic treatment.³

Surgical Treatment

A number of surgical techniques have been reported^{3-5,7,8} and vary based on the type and location of the disease.

Surgical procedures are classified depending on the topographic anatomy:

- Surgery of the external ear
 - Surgery of the ear pinna
 - Surgery of the ear canal
- Surgery of the middle ear (tympanic bulla)

SURGERY OF THE EXTERNAL EAR

Surgery of the Ear Pinna

Amputation of the ear pinna: Indications for partial amputation of the ear pinna (not including the ear canal) are mostly represented by trauma and neoplasia. Blood vessels included in the portion of the ear pinna to be removed are ligated. Skin incisions are performed on both sides of the ear pinna, and the skin is bluntly separated from the surrounding cartilage of the auricle. Chondrotomy is performed with scissors a bit more proximal than the skin, in order to allow a skin-to-skin suture of the margins. Suture is routine in an interrupted pattern with non-absorbable material.

Treatment of otohematoma: Otohematoma is not frequent in rabbits, but it may follow repeated shaking and scratching of the ear pinna because of bacterial or parasitic otitis externa. The surgical approach is from the scapha, where an S-shaped skin incision is performed over the hematoma. Serum is drained and absorbed with sterile gauze, and blood clots are removed with gentle pressure over the ear pinna.¹⁰ The site is then thoroughly flushed to remove additional fibrin clots. In order to prevent pockets left in which fluids can accumulate, several mattress sutures are placed full thickness, transfixing the cartilage of auricle and the skin on both sides of the ear pinna. Sutures should be placed vertically rather than horizontally.¹⁰ The skin incision is not sutured. Bandage of the ear pinna is not necessary.

Surgery of the Ear Canal

Lateral Ear Canal Resection

The lateral ear canal resection (LECR) is aimed to create a wider and more proximal lateral opening of the ear canal for treatment and management of the otitis externa, removing exudate and performing flushing of the ear canal.^{4,8} Indication is otitis externa without otitis media or severe disease of other ear canal structures. This is particularly important in the lop rabbit because of the different anatomy of the ear canal. From the surgical standpoint it represents a permanent otostomy, where the cavity is represented by the ear canal. For this reason it is also commonly "otostomy." However, this terminology is generic, and it may be applied also to other different techniques and approaches of surgery of the ear.

The standard LECR is performed removing most of the lateral wall of the ear canal (usually, the entire cartilage of the tragus via a total chondrectomy of that specific cartilaginous plate).^{4,8} Two parallel skin incisions are made on the lateral aspect of the ear canal, parallel to the long axis of the ear pinna and canal. Additional local anesthetic block can be performed before skin incisions. In case of standard LECR, the skin incisions start from the border of the opening, to the proximal aspect of the ear canal. The flap of skin between the two incisions and associated subcutaneous tissue are bluntly dissected free from the underlying cartilaginous plates and reflected rostrally, in order to expose the tragus and part of the helices. The flap is then resected transversely at the proximal end, and removed. The tragus is separated from the two helices and

removed, including the scutiform cartilage. Hemorrhage is usually minimal and it can be easily controlled with cotton tip applicators, radiosurgery, or other hemostatic devices.

The normal anatomy may be significantly altered in cases of empyema and dilation of the ear canal, in particular in lop rabbits where the flexible tragus can be ruptured.

When the purpose of standard LECR is to treat (or to prevent) otitis externa only, and when involvement of the proximal portion of the ear canal within the CAM and of the bony acoustic meatus are not present, the CAM is not removed, in order to use it for the suture to the adjacent skin, and keep the acoustic duct well patent. Skin is sutured over the free margins of the helices, and to the margins of the cartilage of the acoustic meatus, creating a stoma over the bony acoustic meatus.

However, different variations of this surgical technique can be performed depending on one or more of the following elements: kind of patient (standard or lop rabbit); extension of the otostomy; presence of empyema of the ear canal; deformity, ectasia, or rupture of the ear canal; final cosmetic appearance; and surgeon's preference.

When wider otostomy in a proximal direction is pursued (more frequently in the lop rabbit) the anular cartilage of the acoustic meatus is removed as well, dissecting it from the bony acoustic meatus of the tympanic bulla. The LECR is therefore performed via a double, total chondrectomy (tragus, and CAM). This technique would be properly named total lateral ear canal resection, because the lateral wall of the ear canal is removed from the distal natural opening to the most proximal end possible.

Another option is to avoid the excision of the tragus, just flexing and suturing it to the dorsal helix and the adjacent skin. In this case, the permanent otostomy is performed via a single chondrotomy, rather than the chondrectomy of the tragus. This surgical technique is not associated with excision of the cartilage of the acoustic meatus.

The LECR may also be partial, performing the partial chondrectomy of the tragus. This technique undergoes a different terminology, and is reported below. This approach is usually combined with excision of the cartilage of the acoustic meatus.

In case of empyema of the tympanic bulla or otitis media, most LECRs can also be combined with the surgical approach to the bulla, in particular with the lateral bulla osteotomy/ostectomy (LBO).

The standard LECR and the LECR via simple chondrotomy represent an exception because they do not include the excision of the cartilage of the acoustic meatus. Instead, the combined surgical technique LECR + VBO must include chondrectomy of that anular cartilage.

Total Ear Canal Ablation

Indication is for cases of severe infection, stenosis of the entire ear canal, or neoplasia. Total ear canal ablation (TECA) includes removal of all the cartilages of the external ear canal.^{3-5,7,8} A single skin incision is made on the lateral aspect of the dilated ear canal, parallel to the long axis of the ear pinna and canal. The subcutaneous tissue is bluntly dissected from the lateral cartilages of the ear canal (the tragus, and part of the helices). In lop rabbits, the flexion of the tragus may be ruptured, and the ectasia of the ear canal may be represented by the modified skin of the ear canal. The vertical tract of the ear canal is dissected from surrounding tissues (including the skin of the scapha on the medial side) without being entered. Dissection is continued proximally to include the CAM, which is dissected from the bony acoustic duct. After the tympanic bulla is surgically addressed (lateral bulla osteotomy is described below) the subcutaneous tissue and the skin are sutured over the vertical portion of the ear canal. Instead, marsupialization is performed over the tympanic bulla, creating a new opening for postoperative flushing.

Partial Ear Canal Resection

Partial ear canal resection (PECR) represents a lateral otostomy. Previously reported as partial ear canal ablation (PECA),^{5,8} this surgical technique is actually a partial lateral resection of the ear canal, and approaches the empyema of the external ear canal and the otitis similarly to other thick, encapsulated abscesses in the rabbit.

In many rabbits, especially lop rabbits, pus accumulates at the base of the ear canal at the junction of the tragus with the cartilage of the acoustic meatus. In case of PECR, only the proximal portion of the tragus is removed, along with the cartilage of the acoustic meatus. While seldom performed in standard (non-lop) rabbits, this technique results in a better cosmetic outcome than lateral ear canal resection or TECA.

For PECR, the skin is incised over the swelling. The soft tissues delimiting the empyema are separated from adjacent tissues using blunt dissection. Once isolated, the proximal portion of the tragus with the scutiform cartilage, and the cartilage of the acoustic meatus are removed. Lateral bulla osteotomy is performed if indication is present. Once surgery is completed, a stoma is created by suturing skin to subcutaneous tissue and surrounding remaining cartilage for postoperative flushing and healing of margins by secondary intention.

Surgery of Para-Auricular Abscesses

In case of severe lysis of the tympanic bulla subsequent to chronic empyema, para-auricular abscesses can be present around the base of the ear canal. They may or may not be associated with otitis externa and empyema of the ear canal, and are surgically addressed with the standard technique for abscesses. Adjunct surgical technique for the ear canal may be necessary, as well, cleaning and flushing of the ruptured tympanic bulla followed by marsupialization.

SURGERY OF THE MIDDLE EAR (TYMPANIC BULLA)

Lateral Bulla Ostotomy

Indication is for empyema of the tympanic bulla with or without severe otitis media.^{4,5,8} It can be combined with lateral (standard or partial) ear canal resection, or with total ear canal ablation. The lateral aspect of the bulla is approached from the bony acoustic meatus. The minimal lateral osteotomy is aimed to slightly open and enlarge the bony acoustic duct, allowing intraoperative flushing of the exudate. While some references describe osteotomy using rongeurs or other cutting instruments,⁵ the author recommends careful burring with the use of a high-speed dental drill and fine burrs. In severe cases, the bulla is already lytic and ruptured; therefore, wider osteotomy is performed via a thorough, deeper debridement. After accessing the bulla, pus is gently removed and the bulla flushed carefully. More aggressive debridement and use of a curette may result in damage, especially to the medial aspect of the bulla, with production vestibular disease or worsening, if already present. At the end of the surgical procedure, the skin is sutured to the subcutaneous tissue around the opening of the bulla for continued postoperative drainage and flushing.

Ventral Bulla Ostotomy

The ventral approach is medial and parallel to the mandibular angle.^{3,7} Reported advantages include improved exposure, less risk of damage to the hypoglossal and facial nerves, and improved drainage.^{3,7} Since drains for postoperative flushing are difficult to place and maintain in rabbits, the bulla can be filled with AIPPMA beads. This approach may or may not be associated with other surgical treatment of the ear canal.

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