Journal of the Hellenic Veterinary Medical Society

Vol 71, No 3 (2020)

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doi: 10.12681/jhvms.25068

J HELLENIC VET MED SOC 2020, 71(3): 2251-2260
ΠΕΚΕ 2020, 71(3): 2251-2260

Research article
Ερευνητικό άρθρο

Surgical Management of Orbital Abscesses in Domestic Rabbits *(Oryctolagus cuniculus)*: A report of seven cases

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ABSTRACT: A case series of seven domestic rabbits with profound exophthalmos and epiphora are presented. Appetite and physical activity of the animals were mildly or severely reduced. Clinical and detailed ophthalmic examination including intraocular pressure measurements were performed, along with radiographic and ultrasonographic examination. In all animals retrobulbar masses were diagnosed forcing the globe to protrude. Teeth malocclusion was also noticed in most of the animals. Surgical intervention under general anaesthesia, included abscess drainage, flushing and teeth removal. During surgery, samples for bacterial culture and cytology exanimation were obtained. *Pasteurella multocida*, *Staphylococcus* spp and *Pseudomonas* spp were isolated, while cytology confirmed the clinical diagnosis of abscess formation. Surgical management resulted in retropulsion of ocular bulbi and infection elimination. Marsupialization of the abscesses facilitated flushing and topical antibiotic application postoperatively. Animals were treated postoperatively with antibiotics for at least one month, analgesics, daily wound flushing by the owner and regular debridement. Six months after surgery three rabbits had no ocular symptoms while two died in the first two months post surgically, one was lost to follow up and the other died due to unrelated cause. In conclusion, treatment of retrobulbar abscesses in rabbits may be challenging and unrewarding. Surgical management of retrobulbar abscesses without enucleation is a feasible approach, permitting vision-retaining, whereas a multimodal approach consisting of a combination of surgical and medical treatment is often necessary for a successful outcome. The owner should be informed for the long lasting postoperative care as well as the high percentage of relapse.

Keywords: abscess, rabbit, retrobulbar, surgery.

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Date of initial submission: 20-09-2018
Date of revised submission: 22-04-2020
Date of acceptance: 13-06-2020

ΠΕΡΙΛΗΨΗ. Στην παρούσα εργασία μελετηθήκαν 7 κατοικίδια κουνέλια, τα οποία παρουσίαζαν οπισθοβολβικό απόστημα. Όλα τα κουνέλια προσκομίστηκαν με εξόφθαλμο και επιφορά, ενώ παράλληλα εμφάνιζαν ήπια έως σοβαρή μείωση της όρεξης και της φυσικής δραστηριότητας. Διενεργήθηκε κλινική και λεπτομερής οφθαλμολογική εξέταση με έμφαση στη μέτρηση της ενδοφθάλμιας πίεσης, καθώς και ακτινολογική και υπερηχογραφική εξέταση. Σε όλα τα ζώα διαπιστώθηκε η παρουσία οπισθοβολβικών μαζών, ενώ στα περισσότερα ζώα παρατηρήθηκε και ανώμαλη ανάπτυξη των δοντιών. Σε όλα τα ζώα πραγματοποιήθηκε, υπό γενική αναισθησία, χειρουργικός καθαρισμός και παροχέτευση των αποστημάτων, πλύσεις και εξαγωγές δοντιών. Κατά τη διάρκεια της χειρουργικής επέμβασης, λήφθηκαν δείγματα για καλλιέργεια και κυτταρολογική εξέταση. Τα βακτήρια που απομονώθηκαν ήταν *Pasteurella multocida*, *Staphylococcus* spp και *Pseudomonas* spp, ενώ η κυτταρολογική εξέταση επιβεβαίωσε την κλινική διάγνωση των αποστημάτων. Η χειρουργική αντιμετώπιση είχε ως αποτέλεσμα την οπισθοχώρηση των οφθαλμικών βολβών και την αντιμετώπιση της λοίμωξης. Η μαρσιποποίηση των αποστημάτων διευκόλυνε τις πλύσεις και την τοπική χορήγηση αντιβιοτικών μετεγχειρητικά. Στα ζώα χορηγήθηκαν αντιβιοτικά για τουλάχιστον ένα μήνα, αναλγητικά, ενώ πραγματοποιούνταν καθημερινές πλύσεις από τον ιδιοκτήτη και τακτικοί καθαρισμοί στο ιατρείο. Έξι μήνες μετά, τρία κουνέλια δεν είχαν οφθαλμικά συμπτώματα, ενώ τρία πέθαναν τους πρώτους δύο μήνες μετά από τη χειρουργική επέμβαση και σε ένα η έκβαση δεν είναι γνωστή. Συμπερασματικά, η χειρουργική παροχέτευση και καθαρισμός των οπισθοβολβικών αποστημάτων χωρίς εξόρυξη του οφθαλμού είναι μια θεραπευτική προσέγγιση που επιτρέπει τη διατήρηση της όρασης στα κατοικίδια κουνέλια. Ο συνδυασμός φαρμακευτικής και χειρουργικής θεραπείας είναι συχνά απαραίτητος για την επιτυχή έκβαση. Η μετεγχειρητική θεραπεία διαρκεί συχνά αρκετές εβδομάδες και η πιθανότητα υποτροπών είναι υψηλή, πράγμα για το οποίο ο ιδιοκτήτης πρέπει να είναι ενήμερος

Λέξεις κλειδιά: απόστημα, κουνέλι, οπισθοβολβικό, χειρουργείο.

CASES HISTORY

Orbital abscesses are a challenging surgical condition in domestic rabbits regarding rabbits regarding its clinical signs, therapeutic approach and outcome, since it may lead to visual deterioration and it is potentially life-threatening. In this case series, seven domestic rabbits were presented in a private referral practice. Signalment and historical data of the animals are presented in Table 1.

Presenting complaints included exophthalmos (1), epiphora (1), ocular trauma (1), nasal discharge (1) and ocular discharge (4) (Table 2). Appetite was retained in most cases with mild fluctuations, while only one rabbit appeared anorectic. Physical activity was characterized as normal in all cases by the owners. In all animal ophthalmic examination included inspection of the bulbi and adnexa, fluorescein and lissamine green corneal stain application, tonometry and ophthalmoscopy. During ophthalmic examination profound exophthalmos was confirmed in all cases. Intraocular pressure and corneal diameter measurements where normal when compared to the contralateral eye, excluding glaucoma and buphthalmos (Figure 1). Central corneal lesions were present in all animals with ulceration in three of them. Eyelid movements were limited in all cases. Anterior uveitis was also noticed in one case (Table 2).

Plain radiographs of the skull were obtained in 5 animals. In three animals (No 1, 2, 3) abnormal radiologic findings were evident (Fig. 2). In one animal (No 5) no abnormalities were found. Ultrasonographic examination of the eye and retrobulbar space was performed in 2 animals (No 1,2). A hypoechoic to anechoic retrobulbar well defined mass was revealed, with hyperechoic foci within the mass that were not casting any shadow, findings compatible with the presence of a retrobulbar abscess (Fig. 3). Fine needle aspiration was performed in those 2 cases under ultrasound guidance. Clinical examination findings of the animals are presented in Table 2.

Table 1. Epidemiological data of seven rabbits presented with retrobulbar abscesses.

No	Age (years)	Weight (Kg)	Sex	Breed	Previous ADD†
1	3	1.4	Male	ND‡	Incisor and upper cheek teeth left and right
2	5	1.5	Male	ND	Incisor and upper cheek teeth left
3	unknown	1.2	Male	ND	Unknown
4	2	3	Female	Mixed	None
5	3	3	Female	Mixed	None
6	3	1.5	Male	ND	Two premolars extraction
7	5.5	2	Male	ND	None

†**ADD**= Acquired Dental Disease
‡ND= Netherland dwarf

Table 2. Clinical appearance and examination findings of seven rabbits presented with retrobulbar abscesses.

No	Presenting complaints	Main clinical manifestation	Eye	Radiology/	Ocular symptoms	ADD
1	Exophthalmos	Exophthalmos-Inappetence	OS*	excessive elongation of the maxillary and mandibular cheek teeth, spur formation, widened of interproximal spaces, root deformity, diffuse irregular mineralization of the adjacent alveolar bone and cheek teeth malocclusion / anechoic well defined retrobulbar mass	Corneal abrasions	Malocclusion of P**+M***
2	Epiphora, nasal discharge	Exophthalmos	OS	excessive elongation of the maxillary and mandibular cheek teeth, spur formation, widened of interproximal spaces, root deformity, diffuse irregular mineralization of the adjacent alveolar bone and cheek teeth malocclusion/ hypoechoic well defined retrobulbar mass	Dacryocystitis, Corneal abrasions	Malocclusion of P+M
3	Ocular discharge	Exophthalmos	OS	excessive elongation of the maxillary and mandibular cheek teeth, spur formation, widened of interproximal spaces, root deformity, diffuse irregular mineralization of the adjacent alveolar bone and cheek teeth malocclusion	Corneal ulcer, iridocyclitis	Malocclusion of upper+lower P+M
4	Ocular discharge	Exophthalmos	OS	None taken	Corneal ulcer, lens luxation, proptosis, dacryocystitis	Malocclusion of P+M
5	Ocular trauma	Exophthalmos	OS	Normal	Corneal melting, lens luxation, staphyloma, dacryocystitis	None
6	Ocular discharge	Exophthalmos	OS	Radiopaque material laterally to OS and periapical to P=+M	Corneal abrasions, edema	Malocclusion of P+M,+ incisors
7	Ocular discharge	Exophthalmos	OS	None taken	Corneal abrasions, edema	Malocclusion of P+M,+ incisors

* **OS**= Oculus sinister
** **P**= Premolar
*** **M**= Molar
ADD= Acquired Dental Disease

Figure 1. Exophthalmos in a rabbit related to a retrobulbar abscess (arrow).

Figure 2. Lateral oblique radiograph of the skull of a rabbit (case 1) demonstrating a radiolucent area of the alveolar bone associated with the upper molar teeth (white arrow), severe deformity of the maxillary and mandible cheek teeth, diffuse irregular mineralization of the adjacent alveolar bone (black arrow) and cheek teeth malocclusion. Malformation of the upper incisor teeth is also evident.

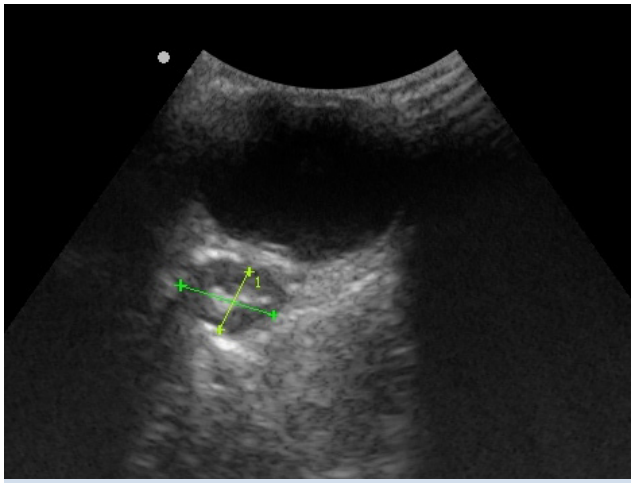

Figure 3. Transverse ultrasonographic section of the eye of a rabbit showing a well-defined 6,16 x 9,24 mm mass hypoechoic retrobulbar mass with echogenic foci in the center of the mass that not casting a shadow (callipers measure the dimensions of the mass).

Surgical intervention was considered curative for 5 animals. In one of them spontaneous abscess drainage took place and, in another animal, no surgical intervention was performed as the owner declined any treatment. All animals were premedicated with medetomidine (Domitor®, Zoetis), (50 μg/kg, intramuscularly) and butorphanol (Butomidor®, Richter pharma) (0.3 mg/kg, intramuscularly). Fluids were administered via an intravenous catheter placed in the auricular marginal vein at a rate of 5 mg/kg/h throughout the surgical procedure. Meloxicam (Metacam®, Boehringer Ingelheim) (0.3 mg/kg, subcutaneously) was administered at the same time. Anaesthesia was induced 10 minutes later with ketamine (Imalgene®, Merial) (10 mg/kg, intramuscularly). Oxygen was provided with a nasal catheter throughout the surgical procedure. After dental care completion, anaesthesia was continued with isoflurane (IsoFlo®, Zoetis) 2-3 % in 100% oxygen provided with a face mask. Reverse of anaesthesia after surgery completion, was achieved with atipamezole (Antisedan®, Zoetis), (0.5 mg/kg, intramuscularly) and was uneventful

Abscess drainage was the was the treatment of choice in most cases following teeth trimming and teeth extraction. A skin incision was performed, based on radiographic, ultrasonographic and ocular palpation findings just above the zygomatic arch (Fig.4) and the abscess cavity was lanced exposing its content (Fig.5). Thick pus was removed with a curette, the abscess cavity was flushed and debrided thoroughly (Fig. 6). At this point exophthalmos was markedly reduced. An intraoral approach and the initial skin incision were both used for teeth extraction avoiding trauma to the adjacent teeth roots (Fig.7, 8). Following abscess flushing, 5-7 sutures were placed in order to keep wound edges apart and enable post-surgical debridement and cleaning (marsupialization). Details concerning abscess location and surgical intervention are presented in Table 3.

Fine needle aspiration of the abscess under ultrasonographic guidance or during surgery yielded a highly viscous, whitish fluid. Cytological smears were prepared using a compression (squash) technique or by rolling a cotton swab along the glass slide. All glass slides were air-dried and stained with modified Wright – Giemsa stain. Microscopic examination of the smears showed accumulation of amorphous, necrotic, eosinophilic, granular material mixed mostly with degenerative heterophils, and lower numbers of macrophages with phagocytized debris (Fig.9). Lym-

phocytes were occasionally observed. No microorganisms were detected. In most of the smears dense extracellular mineral accumulation was also found (Table 3, Fig.10).

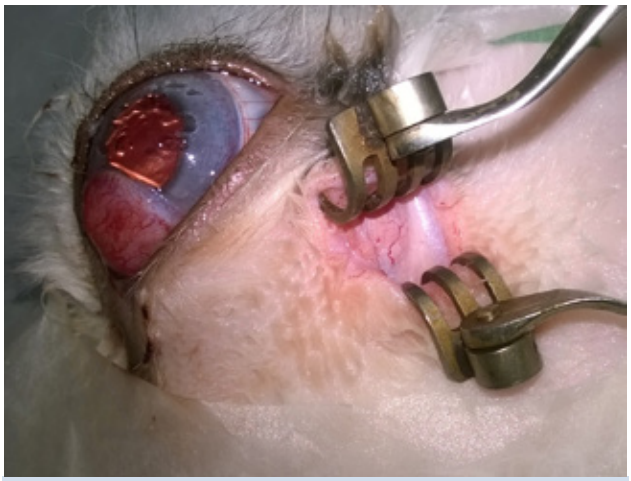

Figure 4. A skin incision was performed just above the zygomatic arch revealing abscess capsule.

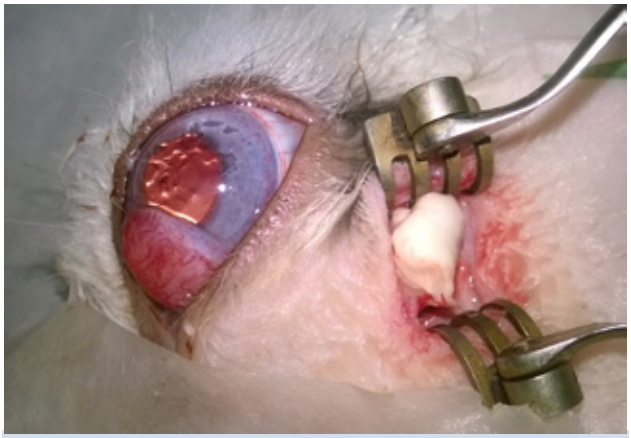

Figure 5. An incision of the abscess's capsule exposing its content.

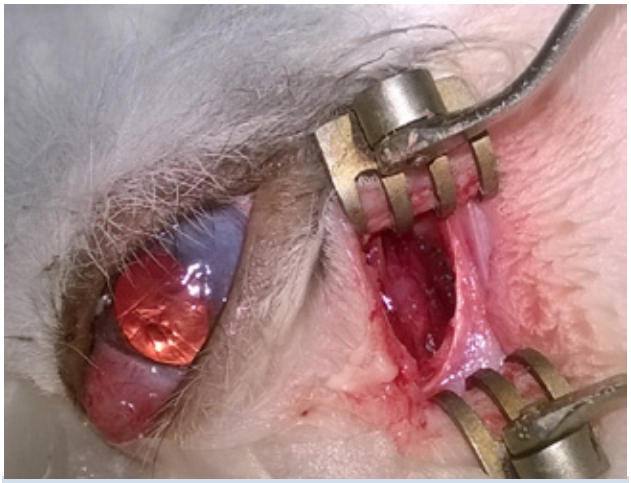

Figure 6. Following pus removal, the abscess cavity was flushed and thoroughly debrided.

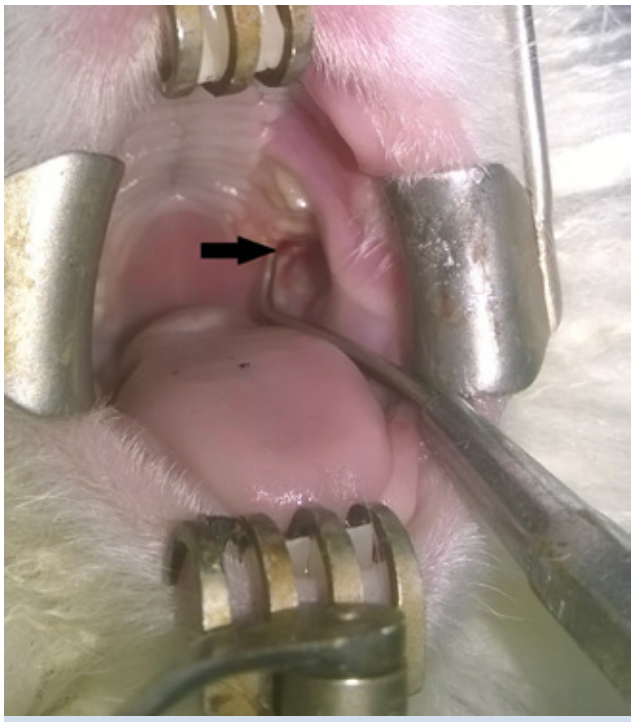

Figure 7. For teeth extraction an intraoral approach, along with the initial skin incision was used.

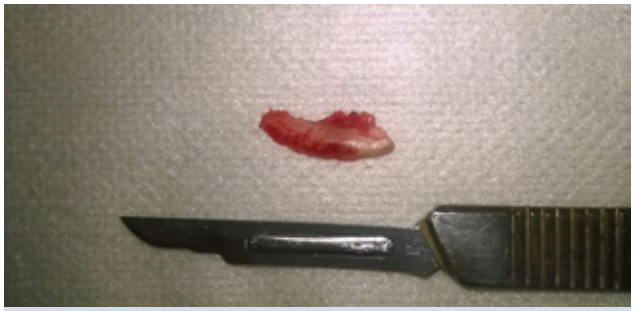

Figure 8. An extracted molar.

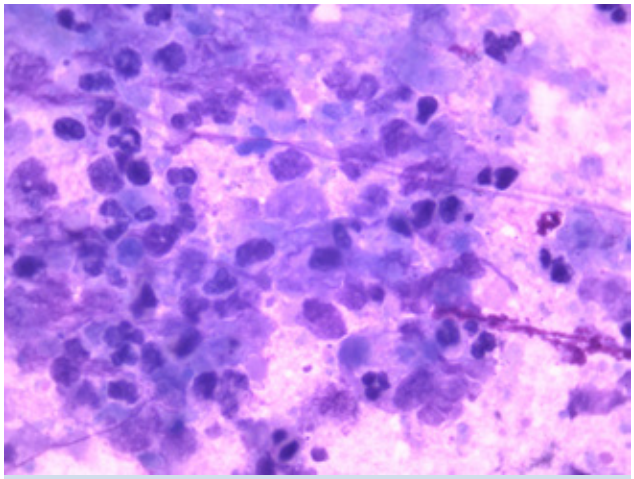

Figure 9. Cytological smear from the orbital abscess in a rabbit. Note the amorphous necrotic eosinophilic granular material mixed mostly with degenerative heterophils, and lower numbers of macrophages with phagocytized debris (Wright – Giemsa x100).

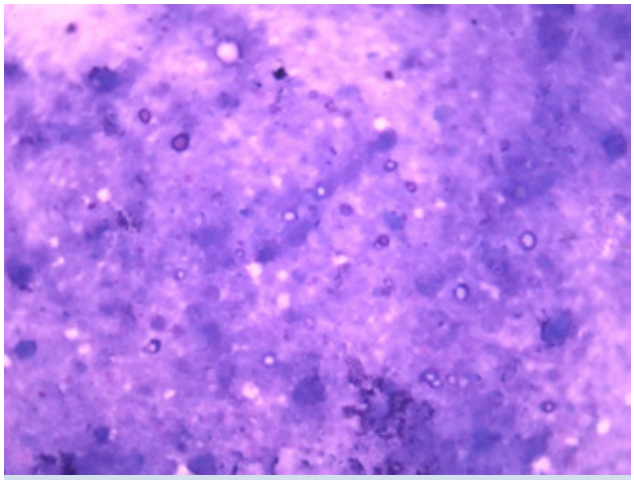

Figure 10. Cytological smear from the orbital abscess in a rabbit. Note the extracellular mineral depositions along with necrotic eosinophilic granular material (Wright – Giemsa x100).

Bacterial cultures obtained during surgery revealed *Pasteurella multocida* in two cases, *Staphylococcus aureus* in one and *Pseudomonas* spp in one case while in another case culture was negative. In two cases the animals died before sampling. Antibiotics were used based on sensitivity test in in a few cases or they were used empirically in those with no bacterial cultures available. Enrofloxacin (Baytril® 0.5%, Bayer), (10mg/Kg, per os, SID) or azithromycin (Zithromax®, Pfizer) (15 mg/Kg, per os, SID) were administered for 1 month combined with topical preparations. Prebiotic supplements were administered simultaneously with antibiotic per os and force feeding in anorectic animals (Tab.3). Post surgically, analgesia was achieved using meloxicam (Metacam®, Boehringer Ingelheim), (0.1mg/Kg, per os, SID) for at least 1 week. The owners were advised to flush the abscess cavity with normal saline daily, while debridement was performed by the referring veterinarian every 4-7 days for a month period to control the infection. Two animals died soon after presentation, one in 2 months after surgery and in an animal, relapse was noted one year later. In two animal no relapse was noticed 6 months post surgically and one was lost to follow up (Table 3).

DISCUSSION

Orbital abscess is usually a chronic condition, which may also affect other organs through vascular or lymphatic bacterial dissemination. Rabbits are usually presented with normal to reduced appetite and physical activity, related to the degree of pain and chewing abnormalities presented. Other possible systemic symptoms may also be noticed, including pain related to pressure exerted to the affected site, anorexia, feeding habits alterations, reluctance to play or move. Pain in rabbits is not so obvious, so it is not always easy for the owner to understand early stages of the disease (Varga and Harcourt-Brown, 2014; Capello, 2016). In our study appetite was reduced only in one case, and was attributed to pain. Physical activity deterioration was not mentioned by the owner; thus, pain should have been of low degree.

Complications related to teeth malocclusion are commonly encountered. Elongated crowns of upper premolars, which may penetrate the buccal mucosa is a possible cause of the disease. Most of the affected animals showed premolar and molar malocclusion, highlighting dental involvement. Incisor malocclusion in two cases was considered secondary. Periapical infections of cheek teeth may result in multiple abscesses formation affecting alveolar bones and extending into the orbit (Ward, 2006; Papadimitriou et al., 2008; Capello, 2016; Benato, 2017).

Orbital abscesses are usually characterized by mild to severe exophthalmos, epiphora, ocular surface disorders and dacryocystitis (Williams, 2007). Corneal abrasions and ulceration may be present due to profound exophthalmos and consequent corneal desiccation. Eyelid inability of complete blinking may leave central cornea unprotected (Williams, 2007). In the present study corneal abrasions were evident in most of the animals, while three of them were suffering from severe ulcers (Table 2).

Dacryocystitis may also predispose to orbital abscess and is commonly associated to *Neisseria* sp., *Moraxella* sp., *Bordetella* sp., *Streptococcus viridans*, *Oligella urethralis* or *Pseudomonas* spp (Marini et al., 1996). It is commonly presented with epiphora accompanied by blepharitis, florid conjunctivitis of the nasolacrimal punctum and facial dermatitis in many cases. Pathogenesis of dacryocystitis involves molar arcades malocclusion with retropulsion of the tooth and incisor malocclusion, causing nasolacrimal duct occlusion. In three dacryocystitis cases presented, this mechanism may explain orbital abscess formation. Dacryocystitis may be also secondary to orbital abscessation via infection dissemination (Jones and Carrington, 1988; Harcourt-Brown, 1996). In one dacryocystitis case of our study (No2), *Pasteurella multocida* was isolated and surgical intervention in molar teeth and orbital abscess reduced clinical signs (Tab. 1).

Table 3. Abscesses position, surgical intervention and post-surgical treatment and outcome of seven rabbits presented with retrobulbar abscesses

No	Abscesses location	Surgical intervention	Dental intervention	Bacterial culture results	Cytology of abscess	Post-surgical treatment	Outcome
1	Medial to OS*+ Periapical to P**+M***	Two incisions medial+ventral OS	Removal of 3rd P+1st M	*Pseudomonas* spp	Amorphous necrotic eosinophilic granular material with degenerative heterophils, a few macrophages. Lymphocytes occasionally observed. No microorganisms were detected. Dense extracellular mineral accumulation.	Fucidic acid eye oint, Enrofloxacin, Meloxicam PO¥, Debridement	Relapse 1 year later
2	Lateral OS	Two incisions lateral+ventral to OS and in ipsilateral mandibular	Extraction of 1st + 2nd M	*aPasterella multocida*	Amorphous necrotic eosinophilic granular material with degenerative heterophils, and few macrophages. Lymphocytes occasionally observed. No microorganisms were detected. Dense extracellular mineral accumulation.	Fucidic acid eye oint, Enrofloxacin, Meloxicam PO, Debridement	Death after two months (possibly unrelated)
3	Lateral OS	One incision lateral+ventral to OS	Extraction of 2nd M	*Staphylococcus spp*	Amorphous necrotic eosinophilic granular material with degenerative heterophils, and few macrophages. Lymphocytes occasionally observed. No microorganisms were detected.	Fucidic acid eye oint, Enrofloxacin, Meloxicam PO, Debridement	No relapse 6 months later
4	Lateral OS	One incision lateral+ventral to OS	Extraction of 3rd P + 1st M	-	Amorphous necrotic eosinophilic granular material with degenerative heterophils, and few macrophages. Lymphocytes occasionally observed. No microorganisms were detected.	Azyter eye drops, Zithromax oral syrup, Florentero oral paste	Unknown
5	Lateral OS	Automatic abscess drainage	None	-	Amorphous necrotic eosinophilic granular material with degenerative heterophils, and few macrophages. No microorganisms were detected. Dense extracellular mineral accumulation.	Baytril oral syrup, Meloxoral oral syrup, Oxatrex eye drops, Vit-a-dEx eye gel	Death
6	Lateral OS, Periapical to P+M	Two incisions lateral+ventral OS and dorsal to cheek teeth	Total incisors extraction, P+M grinding	*Pasterella multocida*	Amorphous necrotic eosinophilic granular material with degenerative heterophils, a few macrophages. No microorganisms were detected.	Zithromax oral syrup, Meloxoral oral syrup, Florentero, Critical Care feeding formula	No relapse 6 months later
7	Lateral OS	None	None	-	Amorphous necrotic eosinophilic granular material with degenerative heterophils, a few macrophages. Lymphocytes occasionally observed. No microorganisms were detected. Dense extracellular mineral accumulation.		Death

* **OS**= Oculus sinister
** **P**= Premolar
*** **M**= Molar
¥ **PO**= per os

Diagnostic imaging techniques are useful to detect the lesion. Computed tomography is considered the method of choice in order to demonstrate the exact anatomic location and extension of the lesion. Radiographic findings of the skull in our cases were also informative showing radiolucent area of the alveolar bone associated with the upper molar teeth (Silverman and Tell, 2005; Capello and Lennox, 2008; Capello, 2016). The location of the above lesion may suggest that the retrobulbar abscess, as demonstrated by ultrasonography, had a tooth root origin. Ultrasonography is also a valuable, fast and safe technique for imaging the retrobulbar space as it may determine preoperatively the exact location and extent of the abscess. The well-defined, hypoechoic or anechoic mass revealed in two cases in our study were compatible with an abscess, even though retrobulbar neoplasms may share similar ultrasonographic signs. The hyperechoic foci in the mass that were not casting a shadow may reflected the presence of necrotic tissue in the abscess (Ward, 2006). The use of specialised ophthalmic ultrasound devices is preferable as they can detect multiple or multilobular abscesses more accurately. In addition to imaging, axial globe direction is helpful clinically in identifying the site of the abscess.

Cytology is a low cost, safe, quick and easy to perform procedure in awake animals (Garner, 2007). Rabbits are good candidates for cytological evaluation, as surgery decision in this species is not undertaken easily, due to their small size and high anaesthetic risk. Cytological characteristics of the material derived from abscesses were similar to those of other companion animal with the exception of heterophils replacing neutrophils. Otherwise, cytological findings were similar of a susceptible or non-susceptible inflammatory lesion in mammals. Absence of bacteria or cocci in the cytological smears was found in 3 of our cases (Table 3), a common finding in the literature (Jenkins, 2001). Facial soft tissues abscesses are common in rabbits. Veterinarians practicing rabbit medicine are familiar with this condition and they usually do not proceed to cytological evaluation and/or culture (Jenkins, 2001). However, other skin and/or subcutaneous lesions may mimic abscesses and should be included in the list of differentials such as basal cell tumour, squamous cell carcinoma, lymphoma, soft tissue sarcoma, lipoma or squamous papilloma, nodular dermal fibrosis and cutaneous treponemiasis. Such lesions can be differentiated using cytology, preventing aimless, expensive and risky diagnostic and surgical procedures (Capello, 2016).

The most common isolated pathogens in this case series, as expected, were *Pasteurella multocida* followed by *Pseudomonas* spp. and *Staphylococcus* spp, while the rest of the animals were tested negative. The negative results were attributed to the method of material collection, as swabbing the purulent content versus swabbing the interior wall of the abscess cavity may result to false negative results. All of our animals were also receiving antibiotic therapy in the time of surgery. Despite negative results broad spectrum antibiotics were administered post surgically in all cases. Pathogens most commonly isolated in rabbit abscesses include *Pasteurella multocida, Staphylococcus* spp., *Proteus* spp., *Bacteroides* spp., and *Pseudomonas* spp., as well as some anaerobic species, such as *Fusiformis* spp. (Deed, 1993; Capello, 2016; Gardhouse et al., 2017). Rational antibiotic therapy was elected based on antibiotic safety, penetrating ability and most commonly bacterial chlora affecting rabbits. Enrofloxacin is the most commonly used antibiotic agent in rabbits, administered in four of the presented cases as it is licensed and is considered a safe choice for prolonged oral use and it was administered in four of the presented cases. Azithromycin which was selected in two cases is another safe antibiotic for parenteral use, indicated for abscesses and osteomyelitis (Varga and Harcourt-Brown, 2014). Ocular antibiotic administration was considered essential for eliminating local infection and preventing dissemination to the globe and conjunctiva. The antibiotics chosen have proved to be safe and effective in ocular infections.

Rabbit anaesthesia protocols were based on animal health status, which were estimated by history and clinical examination findings. Pre-anaesthetic stabilization included hydration, gut motility regulation and efficient food intake and was accomplished by appropriate medical and nutritional support. Oxygen and fluid administration were essential and were administered intraoperatively to maintain appropriate cardiovascular function, especially due to α-2 adrenergic agonists significant cardiovascular side effects. Ketamine was essential for undertaking dental intervention since inhalational anaesthesia via intubation or laryngeal mask would have disturbed intraoral manipulations. Its administration minimized required doses and side effects of other drugs(Meredith and Flecknell, 2006). Inhalational anaesthesia was induced during abscess surgical intervention and was gradually increased to prevent breath holding, a common complication in rabbits (Harcourt-Brown, 2002).

In order to gain direct retrobulbar abscess access in this species, skin incisions are much easier to be performed compared to dogs and cats. This may be explained by the shallower orbit and the higher globe/orbit ratio in rabbits compared to dogs and cats. The abscess capsule was easily detected through the skin incision since it was located directly under the skin. Orbital morphology and abscess location were helpful landmarks to follow to avoid periocular tissue trauma. Appropriate abscess capsule drainage was crucial for eliminating inflammation and preventing relapse, especially when vision was still relapse. Pus material and capsule removal were performed paying great attention not to damage the globe, optic nerve and large venous sinus associated with the orbit glands. When the abscess was located deeper in the orbit, pus removal was more challenging, as the lesion was partially visible. However, if aggressive surgical debridement could not be employed, exenteration might would have been an option (Ward, 2006; Papadimitriou et al., 2008; Capello, 2016; Benato, 2017). In one animal relapse occurred within the first year, something commonly observed following local infection dissemination (Spiess, 2007; Varga and Harcourt-Brown, 2014; Capello, 2016).

In the study presented here if dental involvement was suspected prior to surgery, dental extraction facilitated abscess drainage and infection elimination. Teeth extraction of the upper cheek teeth were essential for periapical abscess treatment. This was accomplished through an oral or extraoral approach through the initial or a second skin incision. Extraoral approach was easier when the maxillary bone was debrided and teeth roots were visible. Intraoral teeth removal carried the risk of incomplete root removal. Cheek teeth were evaluated intraorally in all cases for signs of infection as this contributed in abscess formation.

Postoperative flushing was performed daily at home in our study, followed by application of a topical antibiotic preparation. Owners were trained to perform open wound management at home. Re-examinations continued weekly for at least 1 month. Systemic and topical antibiotics should be administered for 1 month along with prebiotic preparations per os. Appropriate diet and supportive nutrition (Herbivorous Critical care, Oxbow®) is mandatory, while force feeding may be necessary in anorectic cases to maintain proper gastrointestinal flora, motility and function (Papadimitriou et al., 2008; Varga and Harcourt-Brown, 2014). Alternatively, antibiotic-impregnated-polymethylmmethacrylate (PMMA) beads usually used as a bone cement in orthopaedic surgery, could have been elected. PMMA was not used as in its commercial form is combined with certain antibiotics that may not be effective to certain bacteria and no positive effect will be noticed. Another limitation was the impossible post-surgical debridement and flushing of the wound when PMMA is used (Tobias et al., 1996; Ethell et al., 2000). Another alternate topical preparation used is honey due to its hygroscopic and bactericidal properties (Oryan, and Zaker, 1998). In cases of skull abscesses, especially when bones or teeth are involved, rabbits require powerful analgesia. Meloxicam was chosen as it is effective in rabbits and was considered a safe option as long as animals are not debilitated or do not have renal insufficiency (Meredith and Flecknell, 2006; Papadimitriou et al., 2008). Buprenorphine administered orally is an alternative analgesic agent commonly used, but it is not commercially available in our country. Butorphanol may be used as well, but its analgetic action is short and should be given subcutaneously (Meredith and Flecknell, 2006).

Several diseases may lead to a retrobulbar abscess formation in a later stage of the disease, being not always easy to differentiate them. In case No 2, a para-bulbar abscess was suspected due to its location. Para-bulbar abscesses have similar clinical signs, effecting the main or the accessory lacrimal gland. A profound exophthalmos may be evident in such cases, displacing the globe laterally and caudally. In contrast to retrobulbar abscesses, in such cases pus material does not involve the orbital fossa. The treatment is similar to retrobulbar abscesses although, a shorter incision is required, pus removal is easier and marsupialization is not necessary. Post-surgical flushing may be also helpful through a small opening in the incision line and repositioning of the eye should be faster in these cases (Capello, 2016). Infection of the accessory lacrimal gland was not observed in case No 2 during surgical drainage, but it cannot be totally excluded. Other types of facial abscesses may also coexist, such as empyema of the alveolar bulla or the maxillary recess. In the former, medical treatment may be effective, while in the later rhinostomy and pararhinostomy are performed (Ward, 2006; Capello, 2016).

The outcome of appropriately treated cases (No. 1, 2, 3, 6) was satisfactory. In case No 1 an abscess in-

volving a neighbouring area was noted 1 year later and was attributed to recurrence of infection in the area of the second premolar, which had been removed. This rabbit was also the only infected with *Pseudomonas* spp. The outcome of this case was considered satisfactory as it remained free of clinical signs for a year a relatively long period for a rabbit. Case 4 was lost to follow up, while in case No 7 no intervention was attempted as it died soon after presentation. In case No5 owners were reluctant to proceed to any therapeutic intervention. In this case, a probably incomplete automatic abscess drainage occurred few days later, no dental intervention was undertaken and despite medical treatment the outcome was not satisfactory.

Pasteurella multocida infection resulted in encapsulated abscesses which were difficult to cure. Produced pus was thick and caseous and antibiotics usually do not penetrate the abscess cavity due to poor vascularization. Surgical treatment in soft tissue abscesses demands an en bloc removal, as surgical drainage may not be effective. (Deed, 1993; Tyrrell et al., 2002; Varga and Harcourt-Brown, 2014; Benato, 2017; Gardhouse et al., 2017). Sugar or honey preparations are currently used for their bacteriostatic and wound healing properties (Oryan and Zaker, 1998; Gardhouse et al., 2017). Post-surgical treatment has to be prolonged.

Prevention of retrobulbar abscesses in rabbits should include regular teeth inspection every six months or one year, maintaining of normal feeding habits with unlimited hay, grass and a good selection of vegetables offered daily. Selecting breeding stock without congenital teeth disease is also meaningful. The signs of dacryocystitis or globe protrusion may aid the veterinarian to make an early diagnosis of retrobulbar abscessation before severe complications arise.

In conclusion, treatment of retrobulbar abscesses in rabbits may be challenging and unrewarding. A multimodal approach consisting of a combination of surgical and medical treatment is often necessary for a successful outcome. Postoperative care may last for several weeks and the owner should be informed for the high relapse possibility.

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