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Mini Review

DACRYOCYSTOGRAPHY IN RABBITS

Marko Jumake MITROVIĆ[1]*, Anastasija TODOROVIĆ[1], Nikola TATALOVIĆ[2], Aleksandar JANEVSKI[3], Mirjana LAZAREVIĆ MACANOVIĆ[1]

[1]University of Belgrade, Faculty of Veterinary Medicine, Department of Radiology and Radiation Hygiene, Belgrade, Serbia

[2]University of Belgrade, Siniša Stanković Institute for Biological Research – National Institute of Republic of Serbia, Department of Physiology, Belgrade, Serbia

[3]Saints Cyril and Methodius University, Faculty of Veterinary Medicine, Department for Visual Diagnostics, Skopje, North Macedonia

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Abstract

Dacryocystography is a specific method of radiological examination of the nasolacrimal apparatus based on the use of a positive contrast agent, which allows the assessment of morphology and patency. Pathological conditions of the nasolacrimal apparatus in rabbits are very common in clinical practice, and the disturbance of this apparatus' patency is usually a consequence of dental diseases or respiratory infections. The aim of this article is to present the most common pathological conditions that can affect the patency of the nasolacrimal apparatus in rabbits, a detailed anatomical description of the nasolacrimal apparatus in these animals, and the technique for performing dacryocystography.

Key Words: rabbit, dacryocystography, radiology, nasolacrimal apparatus

INTRODUCTION

Rabbits are increasingly kept as pets, and various pathological conditions of the nasolacrimal apparatus are very common in daily clinical practice (Van Caelenberg, 2008;

*Corresponding author – e-mail: markom@vet.bg.ac.rs

Artiles et al., 2020; Hedley et al., 2022). According to Saunders (2013), dacryocystitis is strictly defined as inflammation of the lacrimal sac, although in common usage the term involves other regions of the nasolacrimal apparatus, and usually involves bacterial infection as well as inflammation. The clinical signs of dacryocystitis depend mostly on the primary cause but are usually manifested by epiphora, serous and purulent ocular discharge, conjunctivitis, nasal dysrargia, blepharitis, periocular dermatitis and alopecia, and secondary keratitis (Morera and Martorell, 2005; Williams, 2007; Florin et al., 2009).

Acute conjunctivitis-induced dacryocystitis can lead to transient obstruction of the lacrimal sac, compromising outflow and creating conditions favorable for secondary bacterial infections to occur (Knott, 2014). Cooper (2011) also points out the possibility of spreading infections from the nose to the nasolacrimal apparatus. In particular, some authors emphasize the importance of *Pasteurella multocida* bacteria in the development of lacrimal sac infection and the resulting obstruction of the nasolacrimal apparatus (Marini et al., 1996; Brown, 2006). On the other hand, chronic dacryocystitis usually develops secondary to apical elongation of the reserve crown and periductal osteomyelitis (Varga, 2014). Nasolacrimal apparatus obstruction usually results from apical elongation of the reserve crowns of the maxillary incisors and the first buccal tooth (Saunders, 2013). Less commonly, dacryocystitis may occur due to foreign bodies, polyps, tumors, or traumatic injury (Marini et al., 1996). In a study conducted by Hedley et al. (2022) on a total of 821 rabbits with dacryocystitis, dental problems were observed in 45% of them, while 38% had respiratory infections. The importance of dental disease in the development of dacryocystitis is pointed out by Florin et al. (2009), in whose study dacryocystitis was caused by dental disease in 53% of rabbits, while it was due to rhinitis in 23%.

The anatomical conformation of the head may influence the morphology of the nasolacrimal apparatus, and therefore, brachiocephalic breeds have been found to have a greater tendency to develop nasolacrimal apparatus disease (Harvey et al., 2019). According to Schlueter et al. (2009), the greater the degree of brachiocephaly, the steeper the nasolacrimal apparatus, making it more difficult to drain and creating favorable conditions for the development of infections. Dacryocystitis is particularly common in brachiocephalic rabbit breeds such as Lionheads, Mini-Lops, Lops, and Dwarf Lops (Johnson and Burn, 2019; Hendley et al., 2022).

Dacryocystography is a specific radiological examination method that is inexpensive and easy to perform while providing insight into the morphology of the nasolacrimal apparatus, its diameter, and degree of patency. In this paper, a brief description of the anatomical features of the lacrimal glands and nasolacrimal apparatus in rabbits is given, as well as a detailed description of the dacryocystography technique.

ANATOMY OF THE LACRIMAL GLANDS AND NASOLACRIMAL APPARATUS

Lacrimal glands

The lacrimal gland is an organ that produces and secretes tears, and disruption of the composition, production or release of lacrimal fluid results in a feeling of discomfort and damage to the ocular surface (Bannier-Hélaouët et al., 2021). The lacrimal gland is composed of acini, ducts, nerves, myoepithelial and plasma cells (Hodges and Dartt, 2003; Klećkowska-Nawrot et al., 2016). Acinar cells make up 80% of the gland and secrete a primary fluid consisting of water, electrolytes and proteins. As the primary fluid passes through the ductal systems, its composition changes in the form of increased or decreased amounts of electrolytes (Hu et al., 2021).

Fehr (2016) divided the lacrimal glands of rabbits into orbital, accessory and third eyelid lacrimal glands (Figure 1). Although most mammals appear to have at least one major large orbital gland, adult rabbits have four (Janssens et al., 1999) or five different glandular masses (Kittel, 1962; Kühnel, 1992). The orbital lacrimal gland is located dorsolaterally in the orbit and caudodorsally from the eyeball. The accessory lacrimal glands are divided into retroorbital, retrobulbar and intraorbital lobes and are located along the caudal and ventral margins of the orbit. Inside the third eyelid, there is a superficial gland (nictitans gland) and a deep gland (Harderian gland). All of these glands contribute to tear production, and their secretions are transparent, except for the secretion of the lacrimal gland inside the third eyelid, which is milky white in color and should not be confused with infection. The secretion produced by these glands

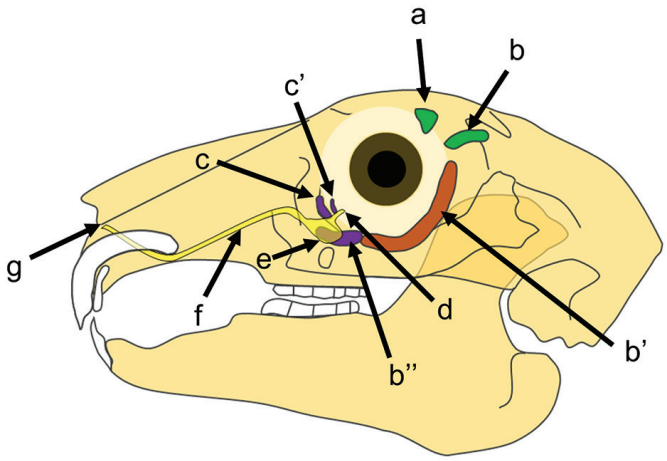

Figure 1. Schematic representation of the nasolacrimal apparatus of the rabbit: a – lacrimal gland; (b-b") - accessory lacrimal glands: b - retro-orbital lobe; b' - orbital lobe; b" - intra-orbital lobe; c – superficial gland of third eyelid; c' - deep gland of third eyelid; d – lacrimal opening; e – lacrimal canaliculus; f – lacrimal sac; g – nasolacrimal duct; h – rostral opening of the nasolacrimal duct.

has the function of moistening, lubricating and washing the surface of the eyeballs, and with further drainage through the nasolacrimal apparatus, the tears enter the nasal cavity (Brown, 2006).

Nasolacrimal apparatus

The function of the nasolacrimal apparatus is to drain the secretion produced by the lacrimal glands into the nasal cavity. The nasolacrimal apparatus begins with a single opening in the form of a slit (Lat. *punctum lacrimale*) in the conjunctiva of the lower eyelid (Hedley et al., 2022), approximately 2-4 mm in diameter and located approximately 3-5 mm from the medial corner of the eye and 3-5 mm from the edge of the lower eyelid. A short (about 2-3 mm long) canal named lacrimal canaliculus (Lat. *canaliculus lacrimalis*) continues from the lacrimal opening, extends ventrocranially and merges into the enlarged portion representing the lacrimal sac (Lat. *saccus lacrimalis*), which is located in the depression (Lat. *fossa*) of the lacrimal bone (Saunders, 2013). A canal named nasolacrimal duct (Lat. *ductus nasolacrimalis*) with an internal diameter of approximately 2 mm continues on the lacrimal sac (Saunders, 2013), passing through the foramen lacrimale of the maxillary bone and extending rostro-ventrally and medially (Burling et al., 1991). In the region of the apical part of the reserve crown of the first maxillary incisor, the nasolacrimal duct bends dorsomedially (between the first maxillary incisor and the nasal cartilage), then extends medially and ends with an rostral opening located a few millimeters from the nasal opening (Saunders, 2013).

Dacryocystography technique

Anesthesia is required to perform dacryocystography. The animal is then placed in a lateral recumbency position (the side of the body on which the patency of the nasolacrimal apparatus is being tested faces the examiner), and a positive contrast agent is administered, followed by radiographic imaging.

Anesthesia:

Certain examination methods (e.g., computerized tomography (CT) and radiographic examination of the head) require anesthesia in rabbits. Because rabbits are unable to vomit, food deprivation prior to anesthesia is not required (Van Caelenberg et al., 2008). Although the use of inhalational anesthetics is widespread in rabbits (Keeble and Meredith, 2006), their use in performing dacryocystography is limited because the inhalation mask may complicate patient positioning and visualization of the nasolacrimal apparatus on X-ray images. Therefore, injectable anesthetics are preferred, and ketamine hydrochloride at a dose of 35 mg/kg body weight with a premedication of 5 ml/kg body weight of xylazine hydrochloride is most commonly used for this purpose in rabbits (Lipman et al., 1990).

Application of positive contrast agent:

The contrast agent is administered through a smaller diameter sterile catheter, although a peripheral venous catheter of 20 to 26 G (Saunders, 2013). The catheter is inserted through the opening of the nasolacrimal apparatus in the medial corner of the eye to a depth of only 1 to 3 mm. The contrast medium is applied in a smaller amount (0.3-0.5 ml) to avoid overflow into the nasal meatuses, which would complicate the view of the nasolacrimal apparatus, and the onset of application should be gentle and with as little pressure as possible to avoid rupture of the wall (Jekl, 2016).

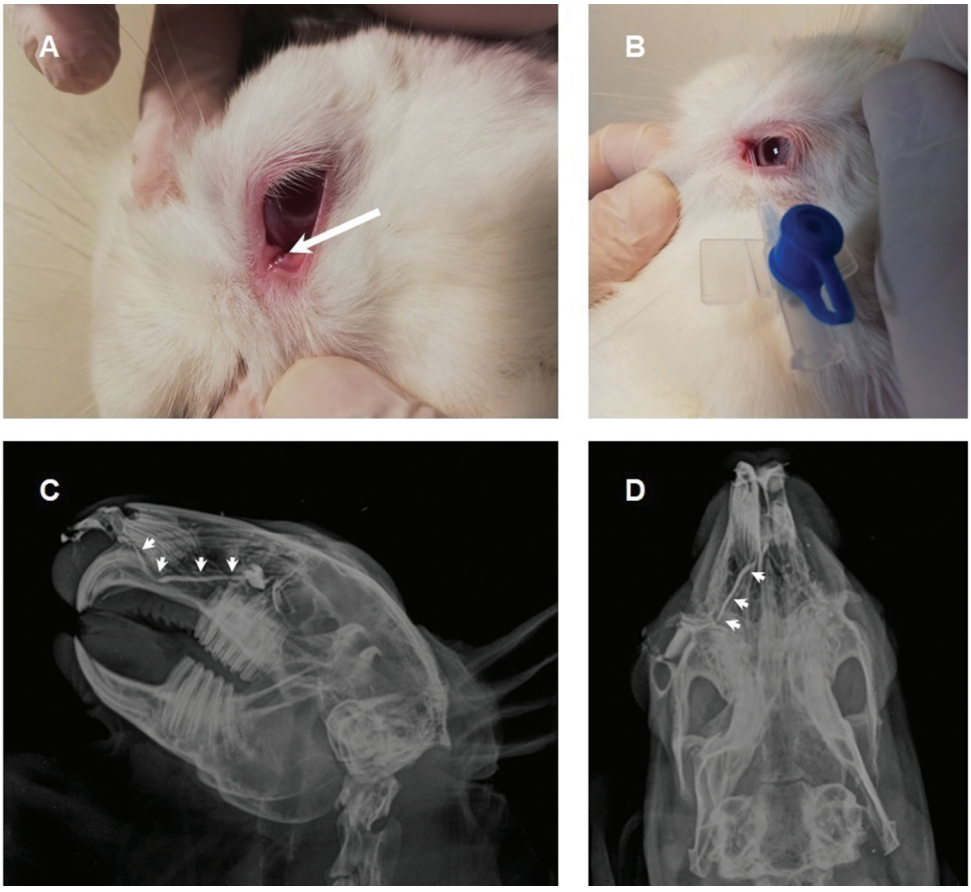

Figure 2. Dacryocystography of a rabbit: view of the lacrimal opening in the medial corner of the eye **(A)**; placement of the catheter **(B)**; X-ray image in latero-lateral **(C)** and dorso-ventral projection **(D)** showing the contrast medium in the lumen of the nasolacrimal apparatus (arrows).

Radiological examination:

When performing dacryocystography, radiological examination should be performed in latero-lateral and dorso-ventral projections. Considering the small body mass of

these animals, the distance between the radiation source and the cassette should be 102 cm, while the voltage and current values should be adjusted to the size of the animal; the recommended values are listed in Table 1 (Silverman and Tell, 2005). Jekl (2016) points out that in young individuals, the voltage value should be reduced by 5 to 10% compared to the recommended values to avoid overexposure of the images and thus allow better visibility of soft tissue structures on X-ray images.

Table 1. Values of tube current and tube potential used in radiological examination of the rabbit head.

Body mass (g)	Tube current (mAs)	Tube potential (kVp)
1200	7.5	54
2200	6	55
4000	6	56-58

To perform the radiological examination in the latero-lateral projection, the animal should be placed in a lateral lying position so that the rostral portion of the head is slightly elevated from the X-ray table and the sagittal plane of the head is parallel to the cassette (Figure 3). The central ray of the X-ray beam should be directed at the level of the premolars and molars, and symmetry of the left and right sides of the head must be achieved on high-quality images (summation of the shadows of the rostral margins of the left and right sides of the orbit, the optic foramina, the coronoid and angular processes of the mandible, and the ventral contours of the left and right mandibles) (Capello and Gracis, 2005).

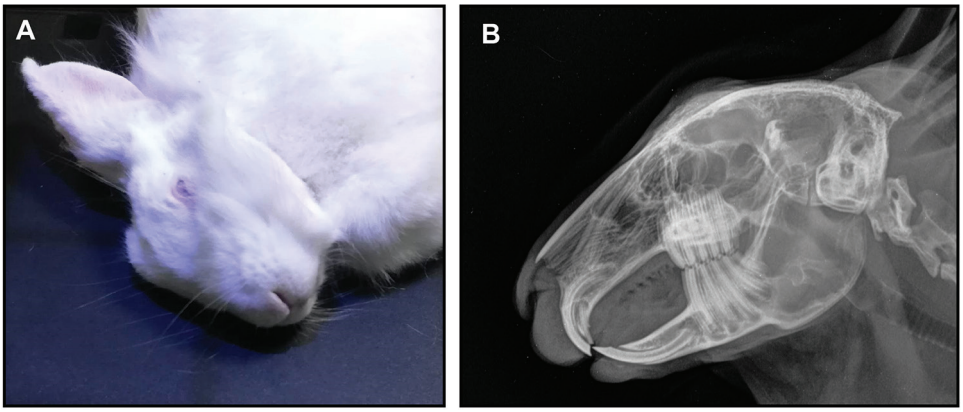

Figure 3. Latero-lateral projection: positioning of the rabbit **(A)**; X-ray image **(B)**.

To perform the radiological examination in the dorso-ventral projection, the animal is placed in the sternal position so that the ventral side of the head (mandible) rests on the radiological examination table (Figure 4), while the direction of the sagittal plane is normal to the cassette (Gracis, 2008).

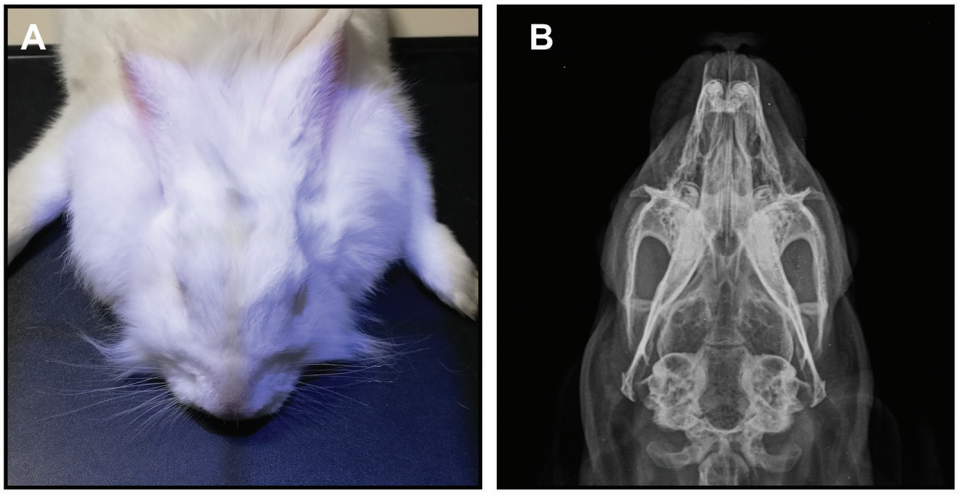

Figure 4. Dorso-ventral projection: positioning of the animal **(A)**; X-ray image **(B)**.

Complications of dacryocystography

In cases of inflammation of the nasolacrimal apparatus (dacryocystitis), the opening in the medial corner of the eye may be narrowed, making catheter placement difficult. In these cases, therapy is required, which includes systemic use of anti-inflammatory drugs and antibiotics (enrofloxacin, meloxicam) and local treatment with flurbiprofen or fusidic acid for one week. In the case of chronic inflammation, fibrosis of the opening of the nasolacrimal apparatus occurs, requiring surgical repair (Saunders, 2013). The same author points out that contrast media must be used with caution because rupture of the nasolacrimal apparatus may occur above the site of obstruction, resulting in periocular swelling and exophthalmos.

CONCLUSION

Examination of the nasolacrimal apparatus with a positive contrast agent is a simple method of investigation that can provide information about its morphology and the degree of its patency. A thorough clinical, intraoral and ophthalmologic examination is required before performing dacryocystography, including bacteriological examination, and in some cases dacryocystography may be preceded by irrigation of the nasolacrimal apparatus.

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Ethical statement

The photographs and X-ray images presented in this article were taken during regular clinical practice by the author (M.MJ.) and are taken and shown with permission of the animal owner.

Authors' contributions

M.MJ., T.A., T.N. and ML. M. conceived of the presented idea and supervised the writing of the manuscript. All authors provided critical feedback and helped shape the research, analysis and contributed to the final manuscript. M.MJ., T.A. and J.A. worked out all of the technical details and designed the figures.

Competing interests

The authors declare that they have no competing interests.

REFERENCES

Artiles CA., Sanchez-Migallon Guzman D., Beaufrère H., Phillips KL. 2020. Computed tomographic findings of dental disease in domestic rabbits (*Oryctolagus cuniculus*): 100 cases (2009-2017). Journal of the American Veterinary Medical Association, 257:313-327. https://doi.org/10.2460/javma.257.3.313.

Bannier-Hélaouët M., Post Y., Korving J., Trani Bustos M., Gehart H., Begthel H., Bar-Ephraim Y.E., van der Vaart J., Kalmann R., Imhoff SM., Clevers H. 2021. Exploring the human lacrimal gland using organoids and single-cell sequencing. Cell Stem Cell, 28:1221-1232.e7. https://doi.org/10.1016/j.stem.2021.02.024

Brown C. 2006. Nasolacrimal duct lavage in rabbits, Clinical techniques. Lab Animal, 35:22-24. https://doi.org/10.1038/laban0606-22

Burling K., Murphy C. J., Curiel JS., Koblik P., Bellhorn RW. 1998. Anatomy of the rabbit nasolacrimal duct and its clinical implications. Veterinary Ophthalmology, 1:33-40.

Capello V., Gracis M. 2005. Anatomy of the skull and teeth. In: Rabbit and Rodent Dentistry Handbook. Ed. Lennox A.M. Wiley, New Jersey, U.S., pp 65-100.

Cooper S. 2011. Dacryiocystitis in rabbits. Companion Animal, 16:19-21. https://doi.org/10.1111/j.2044-3862.2010.00015.x

Fehr M. 2016. Eye and eyelid surgery. In: BSAVA Manual of Rabbit Surgery, Dentistry and Imaging. Eds. Harcourt-Brown F. and Chitty J. British Small Animal Veterinary Association, Gloucestershire, England, pp. 233-239.

Florin M., Rusanen E., Haessig M., Richter M., Spiess B.M. 2009. Clinical presentation, treatment, and outcome of dacryocystitis in rabbits: a retrospective study of 28 cases (2003-2007). Veterinary Ophthalmology, 12:350-356. https://doi.org/10.1111/j.1463-5224.2009.00727.x

Gracis M. 2008. Clinical technique: Normal dental radiography of rabbits, guinea pigs, and chinchillas. Journal of Exotic Pet Medicine, 17:78-86. https://doi.org/10.1053/j.jepm.2008.03.004

Harvey ND., Oxley JA., Miguel-Pacheco G., Gosling EM., Franworth M. 2019. What makes a rabbit cute? Preference for rabbit faces differs according to skull morphology and demografic factors. Animals, 9:728. http://dx.doi.org/10.3390/ani9100728

Hedley J., Ede V., Dawson C. 2022. Retrospective study identifying risk factors for dacryocystitis in pet rabbits. Veterinary Record, 191(5):e1903. doi: 10.1002/vetr.1903.

Hodges R.R., Dartt D.A. 2003. Regulatory pathways in lacrimal gland epithelium. International review of cytology, 231:129-96.

Hu S., Di G., Cao X., Liu Y., Wang Y., Zhao H., Wang D., Chen P. 2021. Lacrimal gland homeostasis is maintained by the *AQP5* pathway by attenuating endoplasmic reticulum stress inflammation in the lacrimal gland of *AQP5* knockout mice. Molecular Vision, 27:679-690.

Janssens G., Simoens P., Muylle S., Lauwers H. 1999. Bilateral prolapse of the deep gland of the third eyelid in a rabbit: diagnosis and treatment. Laboratory Animal Science, 49:105–109.

Jekl V. 2016. Principles of radiography. In: BVSA Manual of Rabbit Surgery, Dentistry and Imaging. Eds. Harcourt-Brown F. and Chitty J. British Small Animal Veterinary Association, Gloucestershire, England, pp. 39-55.

Johnson J.C., Burn C.C. 2019. Lop-eared rabbits have more aural and dental problems than erect-eared rabbits; a rescue population study. Veterinary Record, 185:758. http://dx.doi.org/10.1136/vr.105163

Keeble E., Meredith A. 2006. Rabbit Medicine & Surgery. 1st Edition, Manson Publishing, London, England, pp. 11-12, 25-26.

Kittel R. 1962. Vergleichend-anatomische untersuchungen ueber die orbitaldrüse der rodentia. Wissenschaftliche Zeitschrift der Universitat Halle, 4:401-428.

Klećkowska-Nawrot J., Goździewska-Harlajczuk K., Kowalczyk A., Łukaszewicz E., Nowaczyk R. 2016. Histological, histochemical and ultrastructural studies on Harderian and lacrimal glands of the Capercaillie (Tetrao urogallus major L.). Acta Biologica Hungarica, 67:27-41. https://doi.org/10.1556/018.67.2016.1.2

Knott T. 2014. Ophthalmology. In BSAVA Manual of Rabbit Medicine. Eds. Meredith A., Lord B. British Small Animal Veterinary Association, Gloucestershire, England, pp. 232-254.

Kühnel W. 1992. Morphology of the Harderian gland in the rabbit. In: Harderian Gland: Porphyrin Metabolism, Behavioral and Endocrine Effects. Eds. Webb S.M., Hoffman R.A., Puig-Domingo M.L., Reiter R.J. Springer, Berlin, Germany, pp. 109–126.

Lipman N.S., Marini R.P., Erdman S.E. 1990. A comparison of ketamine/xylazine and ketamine/xylazine/acepromazine anesthesia in the rabbit. Laboratory animal science, 40:395-398.

Marini R.P., Foltz C.J., Kersten D., Batchelder M., Kaser W., Li X. 1996. Microbiological radiographic and anatomic study of the nasolacrimal duct apparatus in the rabbit (Oryctolagus cuniculus). Laboratory animal science, 46:656-662.

Morera N., Martorell J. 2005. Obstrucction del conducto nasolacrimal en conejos. Pequenos animals, 56: 42-48.

Saunders R. 2013. Dental-related epiphora and dacryocystitis. In: BSAVA Manual of Rabbit Surgery, Dentistry and Imaging. Eds. Harcourt-Brown F. and Chitty J. British Small Animal Veterinary Association, Gloucestershire, England, pp. 382-394.

Schlueter C., Budras KD., Ludewig E., Mayrhofer E., Koenig HE., Walter A., Oechtering GU. 2009. Brachiocephalic feline nose. CT and anatomical study of the relationship between head conformation and the nasolacrimal drainage system. Journal of Feline Medicine and Surgery, 11: 891-900. http://dx.doi.org/10.1016/j.jfms.2009.09.010

Silverman S., Tell LA., Nugent-Deal J., Palmer-Holtry K. 2005. Domestic Rabbit (*Oryctolagus cuniculus*). In: Radiology of Rodents, Rabbits, and Ferrets: An Atlas of Normal Anatomy

and Positioning. Eds. Silverman S., Tell L.A. Elsevier/Saunders, St Louis, MO, U.S., pp. 159-230.

Van Caelenberg A., De Rycke L., Hermans K., Verhaert L., van Bree H., Gielen I. 2008. Diagnosis of dental problems in pet rabbits (*Oryctolagus cuniculus*), Vlaams Diergeneeskundig Tijdsschrift, 77: 386-394.

Varga M. 2014. Ophthalmic disease. In: Textbook of Rabbit Medicine (Second Edition), Ed. Varga M., Butterworth Heinemann, Elsevier, p. 350-366.

Williams D.L. 2007. Laboratory Animal Ophthalmology. In: Veterinary Ophthalmology (Fourth Edition), Blackwell Publishing, Oxford, pp. 1336-1369.

DAKRIOCISTOGRAFIJA KOD KUNIĆA

Marko Jumake MITROVIĆ, Anastasija TODOROVIĆ, Nikola TATALOVIĆ, Aleksandar JANEVSKI, Mirjana LAZAREVIĆ MACANOVIĆ

Kratak sadržaj

Dakriocistografija je specijalna metoda radiološkog pregleda nazolakrimalnog kanala, koja se zasniva na upotrebi pozitivnog kontrastnog sredstva i omogućava procenu njegove morfologije i prohodnosti. Patološka stanja nazolakrimalnog kanala kod kunića su veoma česta u svakodnevnoj kliničkoj praksi, a poremećaj njegove prohodnosti je najčešće posledica dentalnih oboljenja ili respiratornih infekcija. Cilj ovog rada je da se ukaže na najčešća patološka stanja koja mogu narušiti prohodnost nazolakrimalnog kanala kunića, detaljan anatomski opis nazolakrimalnog aparata ovih životinja, kao i sama tehnika sprovođenja ove radiološke procedure.

Ključne reči: kunić, dakriocistografija, radiologija, nazolakrimalni aparat.