The Role of Lymphatic Drainage in Disease Prevention and Management in Domestic Animals – a review

Iliana Ruzhanova-Gospodinova, Pavlina Hristova, Silvi Vladova, Seven Mustafa
Faculty of Veterinary Medicine, University of Forestry, Sofia, Bulgaria

Introduction

The lymphatic system plays a **vital role in immune defense, pathogen filtration, and fluid balance** in domestic animals. Acting as a primary filtration network, lymphatic organs help **remove pathogens of various origins**, preventing systemic infections and maintaining immune homeostasis. As in humans, an efficient lymphatic system in domestic animals is essential for **infection resistance and disease recovery** (Johnson, 2021; Steele et al., 2021).

A key aspect of lymphatic function is its **involvement in zoonotic disease transmission**, as certain pathogens exploit the lymphatic network to **disseminate within the host**. Domestic animals can serve as **reservoirs for zoonotic pathogens**, including bacteria, viruses, fungi, and parasites. Diseases such as **rabies, leptospirosis, and brucellosis** not only threaten animal health but also have **severe epidemiological and socioeconomic consequences** for human populations (Aguirre, 2017; Rahman et al., 2020; Noguera et al., 2022).

This review examines the **anatomical structure and functional dynamics of the lymphatic system** in various domestic species, emphasizing its role in **infection prevention and disease management**.

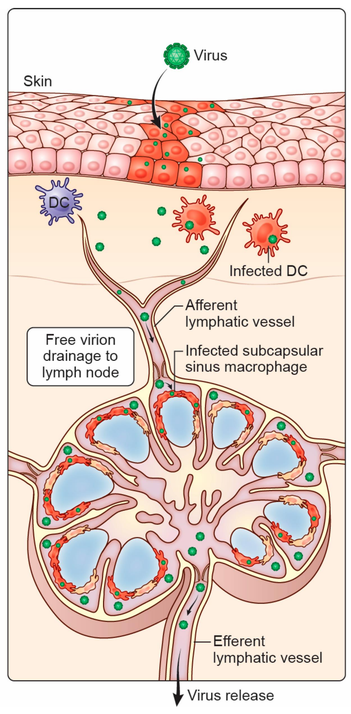

Fig. 1:Viral Infection and Dissemination Through the Lymphatic System (Brisse & Hickman, 2025).

A deeper understanding of lymphatic physiology can lead to **targeted veterinary interventions**, improving **early pathogen detection, disease monitoring, and biosecurity measures**. Furthermore, from a **One Health perspective**, integrating veterinary and public health strategies is crucial for **mitigating zoonotic disease transmission** and safeguarding both animal and human health.

Comparative Analysis: Lymphatic System in Domestic Animal Species

Feature	Ruminants	Equines	Pigs
Lymph Node Architecture	Numerous, segmented nodes (e.g., jejunal, retropharyngeal)	Deep and superficial nodes (e.g., subiliac, cervical)	Numerous lobulated nodes, especially in cervical and mesenteric regions
Unique Organs	Hemal nodes (blood-filtering, node-like structures)	Scattered tonsillar tissue; no distinct palatine tonsil	Hemal nodes (less prominent); large pharyngeal tonsils
Lymphatic Vessels	Extensive thoracic and mesenteric networks	Rich limb plexuses; critical for limb fluid drainage	Well-developed GIT and limb lymphatic vessels
Clinical Relevance	Monitors gut pathogens (*Mycobacterium*, *Brucella*)	Prone to distal limb lymphangitis and cellulitis	Sentinel species for zoonoses (*PRRSV*, *Salmonella*, *Streptococcus*)
Immunological Role	High enteric immune load; constant antigen exposure	Supports immune response under physical strain and vascular load	High mucosal immune activity; intense exposure in intensive farming
Common Disorders	Caseous lymphadenitis, Johne's disease	Chronic lymphangitis, lymphedema	Lymphadenitis, lymph node abscesses, PRRSV-related lymphoid damage

(Casteleyn et al., 2011; Haley, 2017; Bozkurt et al., 2018; Brys et al., 2023)

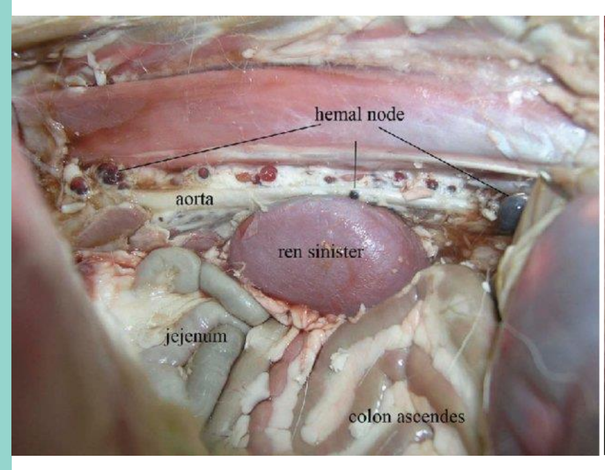

Fig. 2: The distribution of the hemal lymph nodes around the abdominal aorta (Bozkurt et al., 2018).

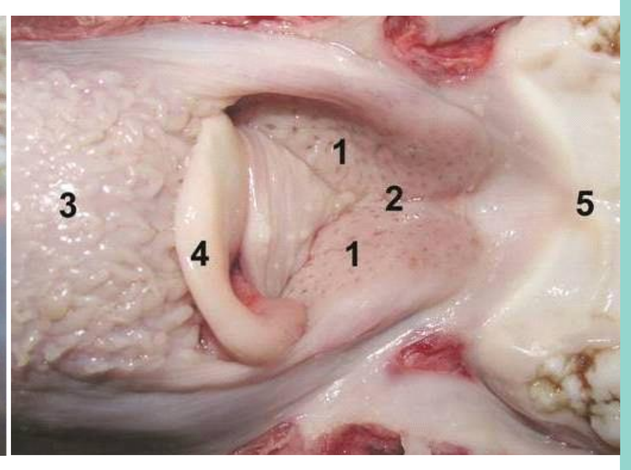

Fig. 3: Swine tonsils: 1 – tonsilla veli palatini, 2 – median palatine line, 3 – tonsilla linguealis, 4 – epiglottis, 5 – palatum durum (Kumar et al., 2017)

Lymphatic Dysfunction and Disease Development

Lymphedema: Though rare in domestic animals, congenital or acquired lymphatic obstruction can result in localized edema, especially post-infection or after trauma. It may manifest as swelling of the limbs or ventral abdomen.

Chronic Inflammation: Inadequate drainage can result in persistent inflammatory responses due to the accumulation of immune cells and inflammatory mediators. This has been noted in chronic dermatitis and mastitis in cattle and dogs.

Metastasis: The lymphatic system plays a crucial role in cancer progression. Tumor cells can spread through lymphatic vessels to regional lymph nodes, which is a known route of metastasis in canine mammary tumors, equine sarcoids, and bovine ocular squamous cell carcinoma (Sleeman et al., 2006; Beer et al., 2018; Polomska & Proulx, 2021).

Role in Autoimmune and Inflammatory Diseases

Bovine Leukemia Virus (BLV): This retrovirus infects B lymphocytes and leads to enzootic bovine leukosis. It often manifests with lymphadenopathy (enlarged lymph nodes), splenomegaly, and compromised immune function (Selim et al., 2020).

Equine Pigeon Fever (*C. pseudotuberculosis*): Causes abscesses in pectoral and ventral lymph nodes, often associated with regional lymphadenitis and lymphangitis (Pratt et al., 2006)

Porcine Circovirus Type 2 (PCV2)-associated disease: PCV2 targets lymphoid tissues, causing lymphoid depletion, granulomatous inflammation, and multisystemic wasting disease (Segalés et al., 2005)

Canine Lymphoma: One of the most common malignancies in dogs, typically involving peripheral lymph nodes and characterized by abnormal lymphocyte proliferation. The disease is directly tied to lymphatic structures and function (Zandvliet et al., 2016).

Applications in Veterinary Medicine and Future Perspective

The Role of Manual Lymphatic Drainage Therapy in Animal Rehabilitation: Manual lymphatic drainage, a gentle massage technique, is increasingly being applied in veterinary physiotherapy. It is used to enhance lymphatic return, reduce post-surgical edema, and promote tissue healing, particularly in equine and canine sports medicine. MLD has shown benefits in improving mobility and decreasing swelling after orthopedic surgery in dogs and horses (Millis & Levine, 2014; Zink & Van Dyke, 2013).

Vaccination Strategies Targeting Lymphatic Function: Modern vaccination strategies aim not only at inducing systemic immunity but also at targeting antigen delivery to lymph nodes, where immune cells initiate responses. Liposomal or nanoparticle-based vaccine carriers have been developed to enhance lymphatic uptake and ensure presentation to dendritic cells and lymphocytes in draining nodes. Such strategies have shown promise in enhancing immunogenicity against pathogens like *Leptospira* and *Brucella* in ruminants and dogs (He et al., 2023). Intradermal and subcutaneous routes are preferred as they promote efficient lymphatic uptake.

Emerging Technologies for Lymphatic Mapping and Diagnostics: Innovations such as near-infrared fluorescence imaging (NIRF), photoacoustic imaging, and 3D lymphatic vessel reconstruction are revolutionizing our ability to visualize and assess lymphatic structures non-invasively. In veterinary contexts, pilot studies in dogs and pigs have demonstrated the utility of indocyanine green (ICG)-based NIRF imaging to map lymphatic drainage and identify sentinel lymph nodes during cancer surgeries (Townsend et al., 2018). These technologies hold promise for earlier diagnosis of lymphatic disorders and for guiding surgical interventions with greater precision. These technologies hold promise for earlier diagnosis of lymphatic disorders and for guiding surgical interventions with greater precision.

Potential Applications in Zoonotic Disease Control: As global awareness of the One Health framework grows, understanding the lymphatic system's role in zoonotic pathogen dynamics becomes increasingly important. Future research may focus on how lymphatic tropism (i.e., pathogen preference for lymphatic tissues) contributes to asymptomatic carriage and transmission in reservoir species. For instance, pathogens like *Brucella abortus* and *Mycobacterium bovis* can persist within lymph nodes, evading immune responses and enabling chronic infection (Atluri et al., 2011). Lymph-targeted vaccines and diagnostic biomarkers could transform zoonotic disease surveillance and prevention strategies.

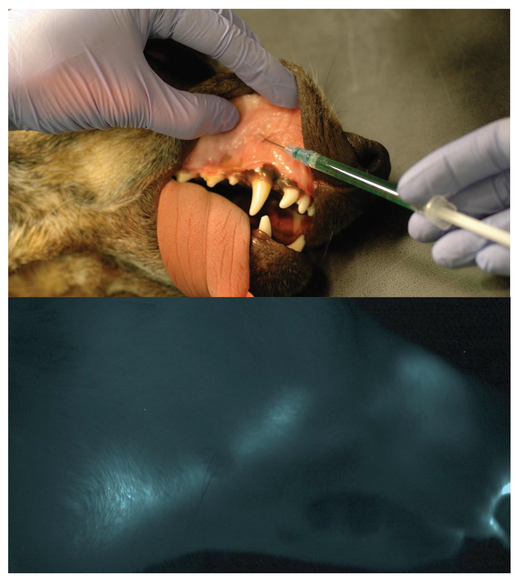

Fig. 4: Submicosal injection of indocyanine green solution and the fluorescence detected under a near-infrared light source in the lymphatic tract and mandibular lymph node (Townsend et al., 2017)

Conclusions

To improve outcomes in veterinary medicine, animal welfare, and zoonotic disease control, continued research is essential. Priorities include mapping lymphatic structures across species, elucidating genetic and molecular regulators of lymphatic health, and developing accessible diagnostic tools. Strengthening our anatomical and functional understanding of this system will be fundamental in preparing for future infectious threats and improving cross-species health security.