# Neutrophil inclusions in a dog

## Contributors

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## Specimen

EDTA whole blood

## Signalment

7-year-old neutered mixed-breed male dog

## History

The dog was presented to the emergency care unit of the National Veterinary School of Toulouse due to apathy, anorexia, presumed abdominal effusion and polyuria/polydipsia for 2 weeks and was referred to the internal medicine unit.

Four years ago, an inflammatory bowel disease responsive to hypoallergenic diet was suspected. Two years ago, a cutaneous mast cell tumor was excised, and five months ago a suspected hepatic infiltration of the tumor prompted initiation of a chemotherapy protocol (vinblastine, lomustine, and prednisolone). Two months ago, immediately following the last chemotherapy session, a decline in the general condition (hyporexia/anorexia, diarrhea, weight loss) necessitated management at another clinical facility due to the holiday period at the National Veterinary School of Toulouse. The animal's condition continued to deteriorate, leading to consultation at the emergency unit of the National Veterinary School of Toulouse.

## Clinical findings

The admission clinical exam revealed a 5% dehydration, tachypnea and an uncomfortable abdominal palpation with abdominal distension.

A complete blood cell count (CBC) with the Sysmex XN-V (Sysmex, Kobe, Japan) and including a blood smear examination (Table 1, Figures 1 and 2), as well as a complete biochemistry panel (Table 2) (Vitros XT3400, Ortho Clinical Diagnostics Inc; CUBE-VET, scil for CRP measurement) and a hemostasis panel (STA Compact Max 3, Stago) were performed. An abdominal ultrasound revealed an effusion and some intestinal changes suggestive of a chronic enteropathy. The complete analysis of the effusion was suggestive of a low protein transudate ($0.70.10^9$ nucleated cells/L; total proteins <10 g/L *via* refractometry).

A first thoracic X-ray was unremarkable except losing contrast due to presence of an abdominal effusion.

**Table 1** - Hematology results (Sysmex XN-V®, Sysmex)

| Variable | Result | | Reference Interval |
|---|---|---|---|
| RBC (.$10^{12}$/L) | **4.26** | | 5.20-7.90 |
| HCT (L/L) | **0.279** | | 0.35-0.52 |
| HGB (g/dL) | **10.3** | | 12.4-19.2 |
| MCV (fL) | 65.5 | | 60.0-71.0 |
| MCH (pg) | 24.2 | | 21.9-26.3 |
| MCHC (g/dL) | 36.9 | | 34.4-38.1 |
| RDW-CV (%) | 14.7 | | 13.2-19.1 |
| RET (%) | 1.51 | | 0.30-2.37 |
| RET (.$10^{9}$/L) | 64.3 | | 19.4-150.1 |
| WBC (.$10^{9}$/L) | **70.03** | | 5.60-20.40 |
| **Differential count** | **Sysmex** | **Manual** | |
| Neutrophils (.$10^{9}$/L) | **67.38*** | **65.10** | 2.90-13.60 |
| Band cells (.109/L) | - | **3.5** | 0-0.30 |
| Lymphocytes (.$10^{9}$/L) | **0.01*** | **0.00** | 1.10-5.30 |
| Monocytes (.$10^{9}$/L) | **2.38*** | **3.50** | 0.40-1.60 |
| Eosinophils (.$10^{9}$/L) | 0.14 | 1.40 | 0.10-3.10 |
| Basophils (.$10^{9}$/L) | 0.12** | **1.40** | Rares |
| PLT-O (.$10^{9}$/L) | **62** | | 108-562 |
| Direct Coombs Test | Negative | | - |

**Abbreviations**: HGB, hemoglobin; HCT, hematocrit; µHCT, microhematocrit; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; MCV, mean cell volume; PLT-O, optical platelet count; RBC, red blood cell count; RET, reticulocytes; RDW-CV, red cell distribution width (coefficient of variation); WBC, white blood cell count; *, error flag; **basophils count not validated with Sysmex XN-V

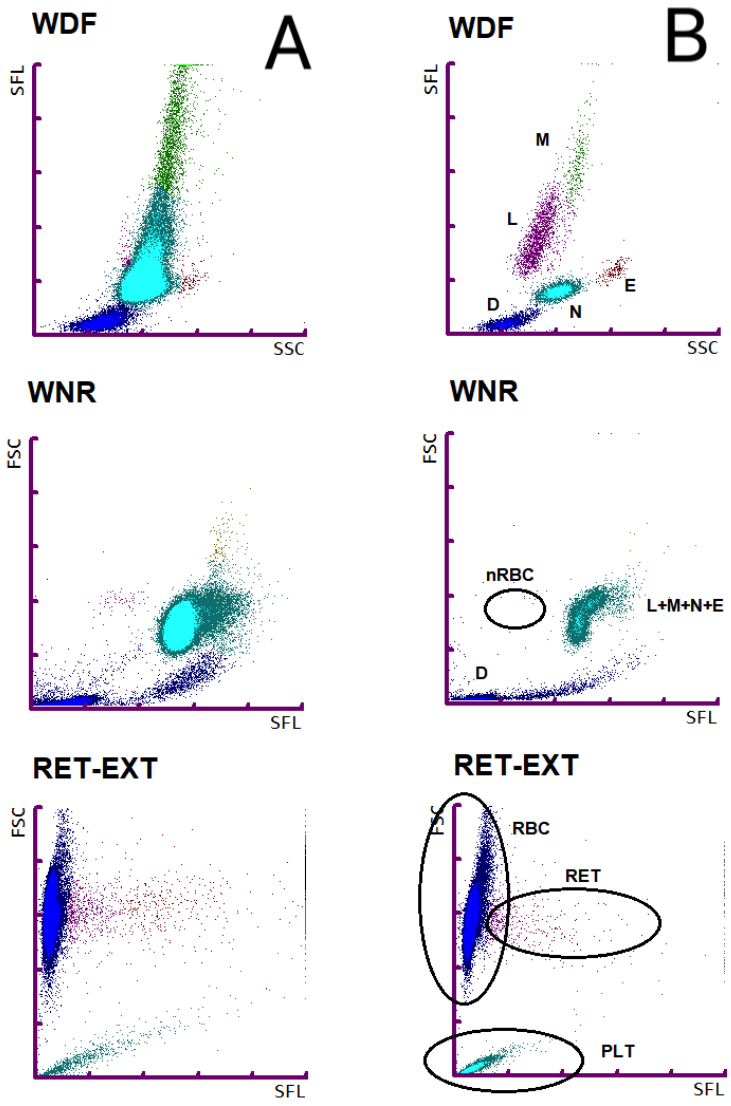


**Figure 1** - Sysmex XN-V® scattergrams from EDTA-blood specimens.

**A**: 7-year-old neutered mixed-breed male dog. **B**: Healthy dog for cell identification.
**Abbreviations**: WDF, WBC differential scattergram; WNR, WBC count scattergram; RET (EXT), Reticulocyte extended scattergram; D, debris; E, eosinophils; L, lymphocytes; M, monocytes; N, neutrophils; nRBC, nucleated red blood cells; PLT, platelets; RET, reticulocytes; RBC, red blood cells; WBC, white blood cells.

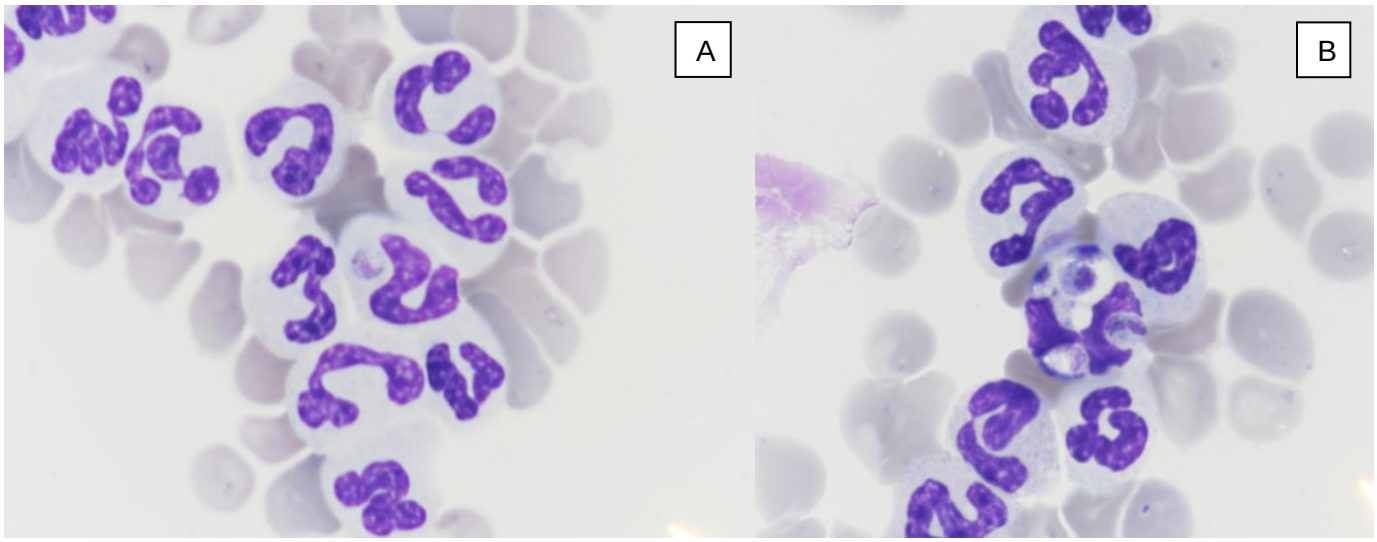


**Figure 2** – A, B: Photomicrographs of the peripheral blood smear of the dog (May-Grünwald Giemsa stain x1000, oil)

**Table 2** - Biochemistry and Hemostasis results (Vitros XT3400, Ortho Clinical Diagnostics Inc.; CUBE-VET, scil; STA Compact Max 3, Stago).

| Variable | Result | Reference Interval |
|---|---|---|
| Glucose (mmol/L) | 5.5 | 3.7-8.2 |
| Urea (mmol/L) | 4.7 | 1.6-10.9 |
| Creatinine (umol/L) | **42** | 44-133 |
| Na (mmol/L) | **130** | 138-148 |
| K (mmol/L) | 4.5 | 3.2-5.0 |
| Cl (mmol/L) | 110 | 110-118 |
| P (mmol/L) | 1.1 | 0.7-2.6 |
| Mg (mmol/L) | **0.4** | 0.7-1.0 |
| Ca (mmol/L) | **1.7** | 2.4-3.0 |
| $CO_{2\ total}$ (mmol/L) | 19 | 16-25 |
| Total Proteins (g/L) | **26** | 48-66 |
| Albumin (g/L) | **14** | 23-39 |
| A/G | 1.17 | >0.80 |
| Cholesterol (mmol/L) | **2.5** | 3.3-9.3 |
| Triglycerides (mmol/L) | 1.2 | 0.2-1.3 |
| ASAT (U/L) | **185** | 1-37 |
| ALAT (U/L) | **388** | 3-50 |
| CK (U/L) | 415 | 25-467 |
| ALP (U/L) | **848** | 20-155 |
| GGT (U/L) | **143** | 5-25 |
| Total bilirubin (µmol/L) | **27.2** | 1.7-12.0 |
| NH3 (µmol/L) | 32 | 0-98 |
| PT (sec) | 9.6 | 7.3-9.9 |
| aPTT (sec) | **18.1** | 12.9-16.9 |
| Fibrinogen (g/L) | 2.49 | 1.3-4.7 |
| Anti-thrombin III (%) | **59** | 102-191 |
| PDF (mg/L) | <5 | 0-5 |
| CRP (mg/L) | **11.7** | <10 |

**Questions**

1 – Based on the CBC results and the WDF and WNR scattergrams, what could be the main causes behind the alert flags and how would you confirm it?

2 – Based on the blood smear examination, what are the main differential diagnosis regarding the neutrophil's inclusions?

3 – What is the most relevant test to determine the nature of the inclusions?

**Interpretation/Diagnosis**

Based on the anamnestic information, clinical presentation, clinical pathological modifications and imagery results, an hepatopathy probably with a toxic origin (lomustin), and a chronic enteropathy (most likely protein losing enteropathy (PLE)) were suspected, along with an inflammatory process.

***Based on the CBC results and the WDF and WNR scattergrams, what could be the main causes behind the alert flags and how would you confirm it?*** The WNR scattergram showed a higher plot density when comparing to a healthy dog scattergram, compatible with a marked leukocytosis revealed by the WBC total count. The WDF scattergram did not reveal well separated populations when comparing with a healthy dog, revealing a fusion between neutrophil, lymphocyte and monocyte populations. The alert flags were linked to the WDF abnormal scattergram, and this last could be compatible with the presence of toxic neutrophils and/or band cells or the presence of basophilia. Blood smear examination would be necessary to confirm the results.

The hematological findings revealed a marked leukocytosis, secondary to a marked neutrophilia associated with a mild left shift and a right shift, mild signs of toxicity and monocytosis associated with reactive monocytes and few macrophages phagocyting tingible bodies and a basophilia. Also, blood smear examination revealed occasional neutrophilic inclusions; these inclusions were round to ovoid shaped, with well-defined borders, pale to slightly basophilic, with a pinkish sometimes granular central to peripherical nucleus-like.

***Based on the blood smear examination, what are the main differential diagnosis regarding the neutrophil's inclusions?*** The main differential diagnoses of these inclusions included an infectious origin such as protozoa (for example *Toxoplasma gondii*, *Neospora caninum,* less likely *Sarcocystis spp. and Leishmania* spp.), and less likely, platelets due the similarity in size and morphology.

***What is the most relevant test to determine the nature of the inclusions?*** A polymerase chain reaction (PCR) blood analysis would be the most relevant test to determine the nature of the inclusions.

This leukogram was mainly suggestive of an inflammatory process and a probable steroid stress. The abnormal elevated basophil count was interpreted as most likely being secondary to the paraneoplastic context (i.e. mast cell tumor) and/or secondary to a parasitic infection.

A mild normochromic normocytic anemia was observed but a definitive cause was not well determined. It is likely that the anemia had a multifactorial origin (inflammation, hepatopathy, and less probably hemolysis/blood loss). The Coombs did not support an immune mediated origin.
Lastly, thrombocytopenia was also observed and confirmed with the blood smear examination (manual count and absence of platelet aggregates), for which the main differential diagnosis were disseminated intravascular coagulation (DIC) and/or an infectious disease (such as vector borne disease) and less likely an immune-mediated origin.

**Additional information**

The dog's serum was tested for *Anaplasma phagocytophilum*, *Borrelia burgdorferi*, *Erlichia cani*s and *ewingii* and to *Dirofilaria immitis* by a commercial ELISA method (SNAP 4 Dx; IDEXX Laboratory). The result was negative to all the agents tested. Also, a polymerase chain reaction (PCR) was conducted at the Scanelis laboratory (Colomiers, France) using EDTA-blood to amplify DNA from *Babesia sp*., *Theileria* sp., *Neospora caninum*, *Leishmania* spp., and/or *Toxoplasma gondii's* DNA. *Sarcocystis* spp. was not tested because this test was not available in France. The test was positive to *Toxoplasma gondi*i. This result led us to further suspect that the neutrophil inclusions were consistent with *Toxoplasma gondi*i inclusions. Additionally, these results did not support an infectious origin of the thrombocytopenia; an immune-mediated origin was not excluded.

**Follow up and clinical outcome**

A thoracic X-ray examination was performed due to the manifestation of respiratory symptoms, revealing a significant alveolar opacification compatible with a bronchopneumonia. The dog was later humanely euthanized due to its deteriorating condition and poor prognosis. An autopsy was not performed.

**Discussion**

This is a case of a dog exhibiting multiple clinical alterations, presumed to be the result of several comorbidities (mast cell tumor, hepatopathy, PLE and bronchopneumonia). The link between these conditions was not fully established and there was not a definitive diagnosis, only strong suspicions based on the anamnesis, laboratory, and imagery findings. The mast cell tumor was the reason behind a three month-chemotherapy treatment that probably triggered an immune depressed condition as well as a supposed toxic hepatopathy. Laboratory findings revealed several modifications including marked leukocytosis associated with a neutrophilia, monocytosis, basophilia and lymphopenia. The CBC was performed using the analyzer Sysmex XN-V and there were several alert flags within the WBC differential count. These alert flags were presumed to be linked with the abnormal WDF scattergram that was not able to adequately separate the neutrophil, lymphocyte, monocyte and basophil populations. As previously described by Grebert *et al.* (2021) and Tvedten & Lilliehööl (2009), the neutrophil population can merge into the lymphocyte population when high band cell concentrations and/or toxic neutrophil changes. Chenal *et al*. (2023) also reported a case of basophilia where basophils were reported to be identified in a cluster close to neutrophils and lymphocytes and being counted in both populations. In our case, the presumed underlying causes for the alert flags and abnormal WDF scattergram were the presence of band cells and toxic neutrophils, activated monocytes and macrophages, significant lymphopenia and marked basophilia. The occasional neutrophil inclusions observed on the blood smear were not considered as one of the causes behind the abnormal WDF scattergram because they were present in very small number. Neutrophilia, monocytosis and the left shift were suggestive of an inflammatory process. Lymphopenia associated with a marked right shift was likely to be at least due to the prednisolone therapy, possible corticoid stress, and an inflammatory process. Basophilia was likely to be secondary to a paraneoplastic condition due to the mast

cell tumor and/or to a parasitic infection (Harvey, 2011; Held & Mochizuki, 2023), and less likely to allergic condition as in dogs it has been mostly reported in association with eosinophilia (Held & Mochizuki 2023). Reported hematological findings in dogs with toxoplasmosis were similar to those observed in our case, including leukocytosis, monocytosis, left shift and lymphopenia, but leucopenia was also reported (Borges-Silva et al*.,* 2021; Pepper et al., 2019; Web et al., 2005). One of these cases (Borges-Silva et al., 2021) also reported the presence of activated monocytes and toxic changes as in our case. An important remark is that these cases had concurrent diseases and received various treatments, including corticosteroids.

The neutrophil inclusions had a morphology compatible with an infectious agent, most likely a protozoan. Our main differential diagnosis of these inclusions were *Neospora caninum, Toxoplasma gondii* and *Sarcocystis* spp. as their morphology may exhibit similarities, but *Sarcocystis* spp. was considered unlikely as it is rarely reported in dogs in France. Less likely, our differential diagnosis included *Leishmania* spp. and platelets. This leads to the need to conduct additional tests such as PCR for definitive identification of infectious agents (Calero-Bernal & Gennari, 2019; Dubey et al., 2020; Lappin & Dubey, 2023; Migliore et al, 2017; Pena et al., 2014), as we did in our case. Cytology might be useful to identify *T. gondii* bradyzoites or tachyzoites in different tissues, effusions, bronchoalveolar lavage fluids, ocular lesions, or cerebrospinal fluid, and they can be found extracellularly or intracellularly with macrophages or neutrophils (Borges-Silva et al., 2021; Falzone et al, 2007; Hawkins et al., 1997; Schlemmer et al., 2018,). To our knowledge, this is a rare case reporting neutrophils inclusions in the circulating blood consistent with *T. gondii* in a dog. Adkesson et al. (2007) reported similar neutrophil and monocyte inclusions consistent with *T. gondii* in a red-necked wallaby (*Macropus rufogriseus*). In this case, the inclusions were further confirmed by immunohistochemistry. In our case, a DNA detection by PCR analysis led us to strongly suspect the origin of this inclusions as *T. gondii* and serology was not performed as the dog was humanly euthanized and due to financial restrictions. Performing an autopsy could have been useful, and if lesions possibly compatible with toxoplasmosis were found, conducting histology and immunohistochemistry would have been of diagnostic interest.

Normochromic normocytic anemia in our case was likely to have multiple causes, including chronic inflammation (due to the mast cell tumor and the PLE) and the hepatopathy. Two cases of dogs with toxoplasmosis were reported to be anemic (with no information regarding the MVC and MCHC) (Pepper et al., 2019; Web et al., 2005) and one case had hypochromic normocytic anemia (Borges-Silva et al., 2021). All three cases had concurrent diseases.

Thrombocytopenia was previously reported in one dog with toxoplasmosis (Borges-Silva et al, 2021), but thrombocytosis was also reported (Pepper et al., 2019). One of our differential diagnoses for thrombocytopenia was an infectious agent (for example *Babesia* sp., *Leishmania* spp.) but PCR and Snap4DX test allowed the exclusion of the main infectious causes. Other important possible cause to the thrombocytopenia in our case is DIC (Harvey, 2011). The biochemistry and hemostasis panel could be consistent with hepatic failure secondary to a toxic hepatopathy and/or hepatic inflammatory disease, but a differential diagnosis to these clinical pathological findings should include both hepatopathy and PLE. Previously reported biochemistry findings in dogs with toxoplasmosis included increased ALP, ALT and GGT

activity, hyperbilirubinemia, hypoproteinemia, and hypoalbuminemia as we observed in our case, but also increased urea, hyperglycemia, hypercholesterolemia, and hypocalcemia (Pepper et al., 2019; Web et al., 2005). As previously mentioned, similarly to our case, these dogs had concurrent diseases so a multifactorial origin to these biochemistry findings is likely. An elevated C-reactive protein (CRP) was suggestive of an acute inflammatory process probably related to the PLE, the hepatopathy and the *T. gondii* infection (Covin & Steiner, 2022; Stockham & Scott, 2008). Lastly, an immune-mediated origin for the thrombocytopenia was not excluded, but it was considered unlikely.

*T. gondii* is a coccidian protozoan that can infect any warm-blooded vertebrate worldwide and has a two-host life cycle, although its definitive host is the cat. Only cats can complete the sexual phase (enteroepithelial cycle), producing oocysts that will be eliminated in feces. The unsporulated oocysts will then sporulate in the environment, becoming constituted by sporozoites. Hosts can be infected by directly ingesting the sporulated oocyst or by ingesting meat infected with bradyzoite cysts. After oocyst ingestion, sporozoites are released and develop into tachyzoites that will actively multiply and quickly spread to several organs. Tachyzoites can penetrate most mammalian cells and replicate asexually within infected cells until the cell is destroyed. In a host with good immune response, the tachyzoites will then convert into bradyzoites that will remain latent in an extra-intestinal cyst form leading to a life-long chronic infection. In the other hand, in cats, bradyzoites cysts ingested by cats can complete the enteroepithelial cycle as previously explained. The dog might be an intermediate host and *T. gondii* is associated with low rate of morbidity and mortality in this species (Calero-Bernal & Gennari, 2019; Dubey et al., 1998; Lappin & Dubey, 2023). The tachyzoite is often like a crescent or “banana” shaped, approximately 2-6 µm, with a pointed anterior end and a rounded posterior end. The nucleus is commonly toward the central area. After entering the host cells, the tachyzoites become ovoid (Burkhard, 2016; Dubey et al., 1998). In our case, the neutrophil inclusions never presented a “banana” shape, as they were often round to ovoid with a central to peripherical nucleus-like.

The development of clinical toxoplasmosis relies on both host factors (definitive or intermediate) and parasite effects. If the host exhibits a compromised immune response or has undergone immunosuppressive treatment, it may lead to an excessive activation of tachyzoites and subsequent tissue necrosis. This is likely to occur in dogs or cats with chronic (latent) toxoplasmosis that subsequently experience immune suppression (Hoffman et al, 2012; Pena et al., 2014; Pepper et al., 2019; Webb et al., 2005). In our case, the dog had been under immunosuppressive treatment for several months due to chemotherapy for its mast cell tumor management. This immunosuppressed condition could be an underlying cause for the development of systemic toxoplasmosis, even though it was not possible to determine whether its clinical condition was or not linked to this supposed infection. As previously discussed, this dog had many clinical modifications (hepatic, intestinal, respiratory damages) that could had a relation or not with *T. gondii* infection. Clinical signs related with toxoplasmosis in dogs are associated with respiratory, gastrointestinal, or neuromuscular infection and may include fever, vomiting, diarrhea, respiratory distress, ataxia, seizures, and icterus (Borges-silva et al, 2021; Dubey et al., 2009; Dubey et al., 2020). There are also reports of myocarditis (Dorsch et al., 2022), cutaneous (Hoffman et al, 2012; Pena et al, 2014; Webb et al., 2005) and ocular disease (Schlemmer et al., 2018; Swinger et al., 2009) in infected dogs.

In conclusion, this was a case of a dog with multiple comorbidities and neutrophil inclusions cytologically consistent with *T. gondii* and with DNA sequencing positive to this parasite. Further investigation would require an autopsy to confirm whether the different lesions observed in our dog could be linked to the infection by *T. gondii*, but unfortunately the owner denied this exam. Finally, the clinical pathologist needs to be aware of this morphology to further integrate *T. gondii* in the differential diagnosis when observing these types of inclusions in the blood smear of the dog and mostly in cases of immunosuppression.

**References**


- Adkesson, M. J., Gorman, M. E., Hsiao, V., Whittington, J. K., & Langan, J. N. (2007). Toxoplasma gondii inclusions in peripheral blood leukocytes of a red-necked wallaby (Macropus rufogriseus). *Veterinary Clinical Pathology*, *36*(1), 97–100. https://doi.org/10.1111/j.1939-165x.2007.tb00190.x
- Borges-Silva, W., Rezende-Gondim, M. M., Galvão, G. S., Rocha, D. S., Albuquerque, G. R., & Gondim, L. P. (2021). Cytologic detection of Toxoplasma gondii in the cerebrospinal fluid of a dog and in vitro isolation of a unique mouse-virulent recombinant strain. *Journal of Veterinary Diagnostic Investigation*, *33*(3), 591–594. https://doi.org/10.1177/1040638721996685
- Burkhard, M. (2016). Respiratory tract. In R. Raskin & D. Meyer (Eds.), *Canine and Feline Cytology* (3rd ed.). ELSEVIER.
- Calero-Bernal, R., & Gennari, S. M. (2019). Clinical Toxoplasmosis in Dogs and Cats: An Update. *Frontiers in Veterinary Science*, *6*. https://doi.org/10.3389/fvets.2019.00054
- Chenal, T., Guerlin, M., Jurrus, M., Tanté, R., Granat, F., & Trumel, C. (2023). What is your diagnosis? Additional cluster on the white blood cell differential scattergram using the Sysmex XN-V hematology analyzer in the blood of a dog. *Veterinary Clinical Pathology*. https://doi.org/10.1111/vcp.13276
- Covin, M. A., & Steiner, J. M. (2022). Measurement and clinical applications of C-reactive protein in gastrointestinal diseases of dogs. *Veterinary Clinical Pathology*, *50*(S1), 29–36. https://doi.org/10.1111/vcp.13100
- Dorsch, M. A., Cesar, D., Bullock, H. A., Uzal, F. A., Ritter, J. M., & Giannitti, F. (2022). Fatal Toxoplasma gondii myocarditis in an urban pet dog. *Veterinary Parasitology. Regional Studies and Reports*, *27*, 100659. https://doi.org/10.1016/j.vprsr.2021.100659
- Dubey, J., Lindsay, D. S., & Lappin, M. R. (2009). Toxoplasmosis and Other Intestinal Coccidial Infections in Cats and Dogs. *Veterinary Clinics of North America. Small Animal Practice/Veterinary*

*Clinics of North America. Small Animal Practice*, *39*(6), 1009–1034. https://doi.org/10.1016/j.cvsm.2009.08.001

- Dubey, J. P., Lindsay, D. S., & Speer, C. A. (1998). Structures ofToxoplasma gondiiTachyzoites, Bradyzoites, and Sporozoites and Biology and Development of Tissue Cysts. *Clinical Microbiology Reviews*, *11*(2), 267–299. https://doi.org/10.1128/cmr.11.2.267
- Dubey, J. P., Murata, F. H., Cerqueira-Cézar, C. K., Kwok, O. C., Yang, Y., & Su, C. (2020). Toxoplasma gondii infections in dogs: 2009-2020. *Veterinary Parasitology*, *287*, 109223. https://doi.org/10.1016/j.vetpar.2020.109223
- Falzone, C., Baroni, M., De Lorenzi, D., & Mandara, M. T. (2007). Toxoplasma gondii brain granuloma in a cat: diagnosis using cytology from an intraoperative sample and sequential magnetic resonance imaging. *˜the œJournal of Small Animal Practice/Journal of Small Animal Practice*, *49*(2), 95–99. https://doi.org/10.1111/j.1748-5827.2007.00421.x
- Grebert, M., Granat, F., Braun, J., Leroy, Q., Bourgès-Abella, N., & Trumel, C. (2021). Validation of the Sysmex XN-V hematology analyzer for canine specimens. *Veterinary Clinical Pathology*, *50*(2), 184–197. https://doi.org/10.1111/vcp.12936
- Harvey, J. (Ed.). (2011). *Veterinary Hematology A Diagnostic Guide and color Atlas* (1st ed.). Saunders.
- Hawkins, E. C., Davidson, M. G., Meuten, D. J., Rottman, J. B., Kennedy-Stoskopf, S., Levy, J. K., Ritchey, J. W., Cullins, L. D., & Tompkins, M. B. (1997). Cytologic identification of Toxoplasma gondii in bronchoalveolar lavage fluid of experimentally infected cats. *Journal of the American Veterinary Medical Association*, *210*(5), 648–650. https://doi.org/10.2460/javma.1997.210.05.648
- Held, E., & Mochizuki, H. (2023). Hematologic Abnormalities and Diseases Associated with Moderate-to-Marked Basophilia in a Large Cohort of Dogs. *Veterinary Sciences*, *10*(12), 700. https://doi.org/10.3390/vetsci10120700
- Hoffmann, A. R., Cadieu, J., Kiupel, M., Lim, A., Bolin, S. R., & Mansell, J. (2012). Cutaneous toxoplasmosis in two dogs. *Journal of Veterinary Diagnostic Investigation*, *24*(3), 636–640. https://doi.org/10.1177/1040638712440995
- Lappin, M., & Dubey, J. (2023). Toxoplasmosis. In J. Sykes (Ed.), *Green's Infectious Diseases of the Dog and Cat* (5th ed.). Elsevier.
- Lilliehöök, I., & Tvedten, H. (2009). Validation of the Sysmex XT-2000iV hematology system for dogs, cats, and horses. II. Differential leukocyte counts. *Veterinary Clinical Pathology*, *38*(2), 175–182. https://doi.org/10.1111/j.1939-165x.2009.00126.x

- Migliore, S., La Marca, S., Stabile, C., Di Marco Lo Presti, V., & Vitale, M. (2017). A rare case of acute toxoplasmosis in a stray dog due to infection of T. gondii clonal type I: public health concern in urban settings with stray animals? *BMC Veterinary Research*, *13*(1). https://doi.org/10.1186/s12917-017-1176-3
- Pena, H. F. J., Moroz, L. R., Sozigan, R. K. B., Ajzenberg, D., Carvalho, F. R., Mota, C. M., Mineo, T. W. P., & Marcili, A. (2014). Isolation and Biological and Molecular Characterization of Toxoplasma gondii from Canine Cutaneous Toxoplasmosis in Brazil. *Journal of Clinical Microbiology*, *52*(12), 4419–4420. https://doi.org/10.1128/jcm.02001-14
- Pepper, A., Mansfield, C., Stent, A., & Johnstone, T. (2019). Toxoplasmosis as a cause of life-threatening respiratory distress in a dog receiving immunosuppressive therapy. *Clinical Case Reports*, *7*(5), 942–948. https://doi.org/10.1002/ccr3.2121
- Schlemmer, S. N., Scott, E. M., Vallone, L. V., Johnson, M. C., Guo, F., & Zhu, G. (2018). What is your diagnosis? Corneal scrape from a dog. *Veterinary Clinical Pathology*, *47*(2), 315–316. https://doi.org/10.1111/vcp.12587
- Stockham, S., & Scott (Eds.). (2008). Liver function. In *Fundamentals of Veterinary Clinical Pathology* (2nd ed.). Blackwell Publishing.
- Swinger, R. L., Schmidt, K. A., & Dubielzig, R. R. (2009). Keratoconjunctivitis associated with Toxoplasma gondii in a dog. *Veterinary Ophthalmology*, *12*(1), 56–60. https://doi.org/10.1111/j.1463-5224.2009.00675.x
- Webb, J. A., Keller, S. L., Southorn, E. P., Armstrong, J., Allen, D. G., Peregrine, A. S., & Dubey, J. (2005). Cutaneous Manifestations of Disseminated Toxoplasmosis in an Immunosuppressed Dog. *Journal of the American Animal Hospital Association/Journal of the American Animal Hospital Association*, *41*(3), 198–202. https://doi.org/10.5326/0410198