
APPLICATION OF THROMBOELASTOGRAPHY IN VETERINARY MEDICINE

Udayasree V. J.

Assistant Professor,
Department of Veterinary Clinical Medicine, Ethics and Jurisprudence
College of Veterinary and Animal Sciences, Mannuthy

Corresponding author e-mail: udayasree@kvasu.ac.in

ABSTRACT

Thromboelastography (TEG) in veterinary medicine is a diagnostic test used to assess the entire blood clotting process. Unlike conventional coagulation tests that assess isolated components of clotting, Thromboelastography analyzes clot initiation, formation, stabilization, and dissolution in real time, utilizing whole blood. This comprehensive evaluation enables the detection of both hypocoagulable and hypercoagulable states, which are crucial in the diagnosis and management of various medical conditions such as immune-mediated diseases, liver dysfunction, hemoprotozoan diseases, neoplasia, and surgical bleeding risks. TEG has demonstrated great utility in transfusion therapy and monitoring anticoagulant efficacy in veterinary patients. Limitations regarding equipment cost, operator competence, and availability prevent its widespread use. Thromboelastography represents a substantial advancement in

veterinary diagnostics, providing clinicians with vital insights into coagulation dynamics that help improve patient outcomes.

Keywords: Thromboelastography, Hypocoagulable, Hypercoagulable, Immune-Mediated Diseases, Transfusion therapy

INTRODUCTION

Thromboelastography (TEG) is a viscoelastic hemostatic assay that measures the global viscoelastic properties of entire blood clot formation at low shear stress. TEG showcases the interaction of platelets with the coagulation cascade aggregation, clot strengthening, fibrin cross-linking, and fibrinolysis. In veterinary medicine, TEG provides a comprehensive insight into coagulation status, which conventional coagulation tests, such as platelet counts, PT, and aPTT, might overlook. The use of thromboelastography is increasingly prominent in veterinary clinical practices for dogs, cats, and horses. (Burton and Jandrey, 2020)

History of Thromboelastography

Thromboelastography (TEG) was developed in 1948, at the University of Heidelberg by Dr. Hellmut Hartert, primarily for use in human medicine. In veterinary medicine, it was used at the beginning of the 1960s in experimental animal studies, focusing mainly on research purposes and not clinical diagnostics. The use of thromboelastography has evolved significantly over the decades in experimental research involving animals such as dogs, pigs, and rats. A notable milestone occurred in Veterinary medicine validating the use of tissue factor-activated TEG in healthy dogs and having widespread interest in utilizing thromboelastography clinically for assessing coagulopathies, guiding transfusion therapy, and managing surgical risks in dogs, cats, and horses (Wiinberg *et al.*, 2005)

Basic Methodology of Thromboelastography

Sample Collection

For thromboelastography, whole blood is collected from animals, most commonly through the jugular vein, using an aseptic technique to minimize contamination and ensure sample integrity. It is essential to avoid venipuncture, as it can likely activate the coagulation cascade and affect test results. Citrate-anticoagulated

blood is used to preserve coagulation factors and maintain the sample in a state suitable for accurate analysis. (Buriko *et al.*, 2023)

Sample Preparation

After collection, blood should be allowed to rest for approximately 30 minutes to help revive platelet function, which is critical for accurate thromboelastography results. In certain diagnostic procedures, coagulation is initiated by adding activators such as kaolin or tissue factor to activate the coagulation cascade and standardize the assessment.

TEG Analyzer setup

In thromboelastography, the blood sample is placed in a gently rotating cuvette, into which a pin suspended by a torsion wire is immersed. As the coagulation process proceeds, fibrin strands form, creating a connection between the rotating cup and the stationary pin. This interaction causes the pin to move in response to the developing clot, and the movement is continuously monitored to assess the dynamics of clot formation and strength (Buriko *et al.*, 2023)

Parameters measured

Each component of thromboelastography provides valuable information about different phases of the coagulation process. Key parameters

include the R-time (reaction time), which indicates the initiation of clot formation; the K-time, indicating the speed of clot formation; and the Alpha (α) angle, which represents the pace of cross-linking and fibrin accumulation. The Maximum Amplitude (MA) evaluates the clot's overall strength, which is primarily influenced by platelet function and fibrinogen levels. Finally, LY30 (lysis at 30 minutes) assesses the degree of fibrinolysis that occurs following clot formation (Wiinberg *et al.*, 2005)

Interpretation of Thromboelastography Tracings

R Time, or Reaction Time, measures the time from the start of the test until the initial formation of a clot, reflecting the initiation phase of coagulation. A prolonged R Time indicates a delay in clot formation, often due to deficiencies in clotting factors as seen in conditions such as liver disease, vitamin K deficiency, or in patients undergoing anticoagulant therapy. (Wiinberg *et al.*, 2005),

K Time, or Kinetics Time, indicates the time required for a clot to reach a defined level of firmness, reflecting the speed of clot development. A prolonged K Time suggests impaired clot formation, often due to abnormalities in fibrinogen levels or function.

Alpha Angle (α) in

thromboelastography is the angle formed between the baseline and the tangent to the TEG curve at the point of R, reflecting the speed of clot formation and the kinetics of fibrin build-up and cross-linking. An increased α -angle indicates a hypercoagulable state, while a decreased α -angle suggests hypocoagulability.

Maximum Amplitude (MA) indicates the maximal strength of the clot and reflects overall clot stability. It corresponds to the highest point of the TEG curve and is primarily influenced by platelet concentration and function, as well as fibrinogen levels.

LY30 measures the percentage of clot lysis 30 minutes after reaching Maximum Amplitude (MA), indicating the degree of fibrinolysis or clot breakdown. Normal LY30 values range from 0–8% in dogs, 0–5% in cats, and 0–3% in horses (Bassan *et al.*, 2023)

Hypercoagulable stage in thromboelastography is characterized by a shortened R and K Time, indicating faster initiation and formation of the clot. It also shows an increased alpha (α) angle and a higher Maximum Amplitude (MA), reflecting accelerated clot development and enhanced clot strength, often associated with an increased risk of thrombosis (Burton *et al.*, 2020).

Clinical Applications of Thromboelastography

Thromboelastography (TEG) is a valuable tool and widely used in human medicine in surgical settings for real-time assessment of a patient's hemostatic status, enabling timely and targeted interventions especially in cardiac surgery, during cardiopulmonary bypass, guides transfusion decisions, reducing unnecessary use of blood products and improving patient outcomes with decreased rates of complications and orthopedic and neurosurgical procedures, TEG helps guide transfusion therapy and manage intraoperative bleeding complications, enhancing patient safety and surgical outcomes (Whitton *et al.*, 2023).

Veterinary Medicine

Epstein *et al.*, (2011) investigated the use of thromboelastography (TEG) in 101 horses with acute gastrointestinal (GI) disease, compared to 20 healthy horses and identified that coagulopathies were frequently present in horses suffering from GI disorders and demonstrated the value of TEG in identifying and characterizing the hemostatic imbalances and impaired coagulation profile in equine gastrointestinal diseases.

According to research (Hanel *et al.*, 2014) dogs with systemic diseases,

particularly hepatic conditions like chronic hepatopathies and acute liver diseases exhibited distinct alterations in thromboelastography (TEG) parameters which included prolonged R (reaction time) and K (clot formation time), increased LY30 (clot lysis at 30 minutes), and decreased alpha angle and MA (maximum amplitude), suggested impaired clot formation and stability. In a study of cats with cholestatic liver disease (Kakar *et al.*, 2021) examined the coagulation profiles using thromboelastography (TEG) and assessed the overall hemostatic balance in affected cats and determined whether they were at risk of bleeding or thrombosis and concluded that TEG as a valuable diagnostic tool for evaluating global coagulation status in cats with cholestatic liver disease, guided individualized treatment decisions such as transfusion or anticoagulant therapy interventions.

TEG played a vital role in the evaluation of coagulation status in dogs with primary immune-mediated hemolytic anemia (IMHA) and in identifying hypercoagulability accelerated clot formation and enhanced clot strength in IMHA cases, aided in the early implementation of anticoagulant therapy to reduce the risk of life-threatening hypercoagulable state as evidenced by shortened K-times, increased alpha angles,

and elevated maximum amplitude (MA) values (Negar and Daniel.,2016)

Acute traumatic coagulopathy in animals was characterized by disruptions in the normal clotting process due to hemorrhagic shock, tissue injury, and systemic inflammation. Thromboelastography was utilized for comprehensive assessment of the coagulation process in trauma, and along with multifaceted treatment approach, early initiation of transfusion therapy, antifibrinolytic agents, such as tranexamic acid, were recommended to reduce the premature breakdown of clots, especially in cases involving contusions to major organs, such as the lungs, liver, or spleen (Drumheller *et al.*, 2019).

Michal Yanai *et al.*, (2024) demonstrated the diagnostic and prognostic utility of thromboelastography (TEG) in heat stroke cases. Thromboelastography provided a comprehensive evaluation of coagulation status, DIC and other hemostatic abnormalities. The result is a hypercoagulable state and systemic inflammatory response syndrome (SIRS), which can progress to disseminated intravascular coagulation (DIC) due to consumption of platelets and clotting factors, as well as impaired hepatic synthesis of coagulation proteins.

Armentano *et al.*, (2014) evaluated hemostatic function using TEG in dogs treated for crotalid snake envenomation and (Lee *et al.*, 2023) used thromboelastography (TEG) to evaluate the coagulation status of dogs envenomated by the Asian pit viper. The researchers hypothesized that most dogs would exhibit hypocoagulable TEG profiles upon normalization within the first 12 hours of treatment. This study underscores the clinical utility of TEG in diagnosing, monitoring, and guiding treatment for coagulopathies associated with snake envenomation in dogs. TEG findings included significantly decreased clot strength, maximum amplitude (MA), and angle value, indicating impaired clot formation and stability, prolonged reaction times (R) and clot formation times (K), reflecting delayed initiation and development of the clot.

Barthélemy *et al.*,(2016) utilized both conventional coagulation tests and thromboelastography (TEG) to assess the hemostatic status of *Leptospira*-affected dogs with anemia, thrombocytopenia, hyperfibrinogenemia and disseminated intravascular coagulation. The study concluded that leptospirosis in dogs were presented with diverse hemostatic alterations and TEG was a valuable diagnostic tool for identifying bleeding risks and prognostic outcomes, with

hypocoagulability potentially indicating a poorer prognosis.

In the study conducted by (Rebecca *et al.*, 2019) thromboelastography (TEG) was employed as both a diagnostic and therapeutic decision-making tool in a series of canine cases presented with hypocoagulable disorders and utilized in blood transfusion therapy. These dogs exhibited impaired blood clotting due to various underlying conditions, and traditional coagulation tests alone were often insufficient to guide precise treatment. TEG allowed for a comprehensive, real-time evaluation of the entire clotting process—from clot initiation to clot strength and dissolution—provided a detailed picture of each dog's hemostatic status. Importantly, TEG was utilized to identify whether administration of fresh frozen plasma (FFP) was necessary, and in what quantity, based on the degree and nature of the coagulation deficit. This individualized approach ensured that FFP was administered only when truly needed and in doses tailored to the severity of coagulopathy, reducing the risk of over-transfusion and related complications. The study emphasized the clinical importance of TEG in optimizing transfusion procedures, increasing patient outcomes, and preserving valuable blood products in veterinary practice. Thromboelastography (TEG) had shown significant value in detecting

hypercoagulable states associated with certain types of cancer, including liver, lung, pancreatic, and prostate malignancies (Kristensen *et al.*, 2008). TEG provided detailed hemostatic assessment, supported earlier diagnosis and treatment planning, and highlighted its potential as both a diagnostic and prognostic tool in veterinary oncology.

Study conducted by (Meriç *et al.*, 2023), a total of 39 dogs—comprising naturally infected dogs in both clinical and subclinical stages of Ehrlichiosis, along with healthy controls—were evaluated using thromboelastography (TEG). The study found that coagulation profiles varied significantly based on disease stage. In clinical canine monocytic ehrlichiosis (CME), platelet dysfunction and thrombocytopenia, caused by bone marrow suppression, increased platelet destruction, consumption, and anti-platelet antibodies, led to hypocoagulability and an increased risk of bleeding. Conversely, dogs with subclinical CME often exhibited hypercoagulability, indicated a higher risk for thrombosis. TEG effectively highlighted differences in clot stability, kinetics, strength, and fibrinolysis, making it a valuable tool for assessing and managing hemostatic disturbances in dogs with Ehrlichiosis.

Inan *et al.* (2024) reported that

dogs affected with Canine Parvoviral Enteritis caused by Canine Parvovirus type 2 (CPV-2) exhibited a hypercoagulable state, reflected by altered TEG parameters as shortened clot initiation times, increased clot strength and reduced clot lysis, indicated a tendency toward excessive clot formation promptly. Hypercoagulability is likely a response to the intense systemic inflammation and endothelial injury seen in parvoviral enteritis, which activated the coagulation cascade and may predispose affected dogs to microthrombi formation and organ dysfunction.

Viscoelastic testing specifically thromboelastography (TEG) was used to assess coagulation profiles in cats diagnosed with acute arterial thromboembolism and revealed that many cats with acute arterial thromboembolism exhibited hypercoagulable TEG profiles, characterized by shortened clotting times and increased clot strength and supported the hypothesis that a prothrombotic state contributed to the development of arterial thromboembolism and guided anticoagulant therapy and improved clinical outcomes (Johnson *et al.*, 2024)

CONCLUSION

Thromboelastography (TEG) has emerged as a transformative diagnostic tool in veterinary medicine, providing a

dynamic and comprehensive assessment of the coagulation process that surpasses the capabilities of conventional coagulation assays such as prothrombin time (PT), activated partial thromboplastin time (aPTT), and fibrinogen concentration. TEG has proven to be useful in critical care and emergency settings in veterinary medicine, including liver diseases, immune-mediated hemolytic anemia (IMHA), sepsis, disseminated intravascular coagulation (DIC), neoplasia, trauma, protein-losing nephropathies, haemoprotozoan diseases and blood transfusion therapy. TEG does not evaluate the contribution of the endothelium to the coagulation process, which plays a crucial role in hemostasis, and results can vary depending on the type of activator used, and they may also be influenced by the patient's hematocrit (HCT) level. The future of Thromboelastography in Veterinary Medicine is promising, with continued developments likely to enhance its diagnostic precision and clinical value. TEG could also play an important role in personalized anticoagulant therapy, perioperative management, and the monitoring of novel antithrombotic drugs, ultimately contributing to more targeted and effective treatment approaches.

REFERENCES

Armentano, R.A., Bandt, C., Schaer, M., Pritchett, J. and Shih, A. 2014.

- Thromboelastographic evaluation of hemostatic function in dogs treated for crotalid snake envenomation. *J Vet Emerg and Crit Care*. **24**: 144–153.
- Barthélemy, A., Magnin, M., Pouzot-Nevoret, C., Bonnet-Garin, J., Hugonnard, M. and Goy-Thollot, 2016. Hemorrhagic, Hemostatic, and Thromboelastometric Disorders in 35 Dogs with a Clinical Diagnosis of Leptospirosis: A Prospective Study. *J Vet Intern Med*. **31**: 69–80.
- Bassan, T., Josep, P., Beatriz, A., Oriol, J. and Jaume, M. 2023. Reference Range of Kaolin-Activated Thromboelastography (TEG) Values in Healthy Pet Rabbits (*Oryctolagus cuniculus*). *Animals*. **13**: 2389
- Buriko, Y., Chalifoux, N. V., Clarkin B, R. and Silverstein, D. C. 2023. Comparison of a viscoelastic point of care coagulation monitor with thromboelastography in sick dogs with hemostatic abnormalities. *Vet Clin Path*. **52**: 217–227
- Burton, A. G. and Jandrey, K. E. 2020. Use of thromboelastography in clinical practice. *Vet Clin North America Small Anim Pract*. **50**:1397–1409.
- Drumheller, B. C., Stein, D. M., Moore, L. J., Rizoli, S. B. and Cohen, M. J. 2019. Thromboelastography and rotational thromboelastometry for the surgical intensivist: A narrative review. *J Trauma and Acute Care Surg*. **86**:710–721.
- Epstein, K., Brainard, B., Gomez-Ibanez, S., Lopes, M., Barton, M. and Moore, J. 2011. Thromboelastography in Horses with Acute Gastrointestinal Disease. *J Vet Intern Med*. **25**:307–314.
- Hanel, R. M., Chan, D. L., Conner, B., Gauthier, V., Holowaychuk, M., Istvan, S., Walker, J. M., Wood, D., Goggs, R. and Wiinberg, B. 2014. Systematic evaluation of evidence on veterinary viscoelastic testing Part 4: Definitions and data reporting. *J Vet Emerg and Critic Care* **24**:47–56.
- Inan, O. E., Levent, P., Saril, A., Hamabe, L., Kocaturk, M. and Yilmaz, Z. 2024. Evaluation of coagulation by thromboelastography and a velocity curve in dogs with parvoviral enteritis. *Veterinárni Medicína* **69**: 345–354.
- Johnson, A. J., Rozanski, E. A., De Laforcade, A. M., Davila, C., Rush, J. E. and Guillaumin, J. 2024. Viscoelastic coagulation monitoring parameters in cats with acute arterial thromboembolism. *J Vet Intern Med* **38**:2045–2058

- Kakar, N., Daniel, G., Fellman, C., De Laforcade, A. and Webster, C. R. 2021. Thromboelastography in cats with cholestatic liver disease. *Journal of feline medicine and surgery*.**5**: 20-24
- Kristensen A.T., Wiinberg B., Jessen L.R., Andreasen E., Jensen A.L.2008. Evaluation of human recombinant tissue factor-activated thromboelastography in 49 dogs with neoplasia. *J. Vet. Intern. Med.* **22**:140–147.
- Lee, J., Jung, Y., Kim, Y., Park, S., Song, J. and Song, K. 2023. Thromboelastographic evaluation in dogs with Asian pit viper envenomation. *J Vet Med Sci.* **85**: 1226–1230.
- Meriç K., Zeki, Y., Ryou,T. and Jose, J. C. 2023. Thromboelastographic Evaluation of Coagulation Profile in Dogs with Subclinical and Clinical Ehrlichiosis. *Kafkas Univ Vet Fak Derg.* **29**: 381-390
- Michal Yanai., Sigal Klainbart., Gal Dafna ., Gilad Segev., Itamar Aroch., Efrat Kelmer., 2024. Thromboelastometry for assessment of hemostasis and disease severity in 42 dogs with naturally-occurring heatstroke. *J Vet Intern Med.* **38**:1483-1497
- Negar, H. and Daniel, L.C.2016. Thromboelastographic assessment of the contribution of platelets and clotting proteases to the hypercoagulable state of dogs with immune-mediated hemolytic anemia. *J Vet Emerg Crit Care.* **26**:295-299.
- Rebecca, L., Louise, B., Jakob, L.W., Tina, M.S. and Annemarie, T.K. 2019. Thromboelastography-guided transfusion in dogs with hypocoagulable disorders: a case series *Acta Vet Scand.* **61**:35-42
- Whitton, T.P. and Healy, W.J. 2023. Review of Thromboelastography (TEG): Medical and surgical applications. *Therap Adv in Pulm and Critic Care Med.* **18**:120-130
- Wiinberg, B., Jensen, A. L., Rojkjaer, R., Johansson, P., Kjelgaard-Hansen, M. and Kristensen, A. T. 2005. Validation of human recombinant tissue factor-activated thromboelastography on citrated whole blood from clinically healthy dogs. *Vet Clin Path.* **34**:389–393.