



A Bibliometric Analysis of Thromboelastography in Veterinary Clinical Use

Oya ERALP INAN^{1.a,*}

¹Eskisehir Osmangazi University, Faculty of Agriculture,
department of Animal Science, Eskisehir, TURKIYE

^aORCID: 0000-0002-4242-8609

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***Correspondence:** Oya ERALP INAN

Eskisehir Osmangazi University, Faculty of Agriculture,
department of Animal Science, Eskisehir, Turkey.
e-mail: oeralp@ogu.edu.tr

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Abstract: The evaluation of coagulation with thromboelastography (TEG) has been of high interest for the last two decades in veterinary medicine. The main cause is the ability to detect hypo-, normo- and hypercoagulative states in a single TEG analysis. In clinical veterinary medicine, the importance of coagulation in terms of course and outcome in many diseases had been realized through research over time. TEG studies had gained importance as traditional coagulation tests were inadequate, especially in cases complicated with hypercoagulation. The bibliometric analysis determined topics, researchers and countries of studies in veterinary clinical use of TEG. According to the Web of Science database, a total of 371 documents in this research field were identified between 1998 and 2023. In 2012, with 39 articles, the highest number of studies were published. The most relevant author was Kristensen A.T. with 39 articles. In the list of corresponding authors' countries, the first country with 189 authors was determined as the USA. Trend topics and their distribution over time have shown that dogs were the most studied animal species in this field. A high number of studies on the topic hypercoagulability and immune-mediated hemolytic anemia were detected, but in the last 3 years new topics like antithrombotics and rational use were involved. The bibliometric analysis carried out showed the changes over time and the currentness of the subject. The results of the present study could be used in planning future studies in the field of veterinary clinical use of TEG.

Keywords: Bibliometrics, Clinic, Thromboelastography, Veterinary.

Veteriner Klinik Kullanımında Tromboelastografinin Bibliyometrik Analizi

Özet: Tromboelastografi (TEG) ile pıhtılaşmanın değerlendirilmesi, son yirmi yıl içerisinde veteriner hekimlikte büyük ilgi görmüştür. Bu ilginin temel nedeni, tek bir TEG analizinde hipo-, normo- ve hiperkoagülatif durumları tespit edebilmesidir. Klinik veteriner hekimliği açısından, birçok hastalığın seyri ve sonucu üzerinde pıhtılaşmanın önemi, zamanla yapılan araştırmalarla fark edilmiştir. Özellikle hiperkoagülasyonla komplike olan durumlarda, geleneksel pıhtılaşma testlerinin yetersiz olduğu durumlarda, TEG çalışmaları önem kazanmıştır. Bibliyometrik analiz, TEG'nin veteriner hekimliği klinik kullanımı alanındaki konuları, araştırmacıları ve ülkeler hakkında bilgi vermiştir. Web of Science veritabanına göre, 1998 ile 2023 arasında bu araştırma alanında toplam 371 belge tanımlanmıştır. İki bin on iki yılında, 39 makale ile en yüksek sayıda çalışma yayımlanmıştır. Yazarlardan Kristensen A.T. 39 makale ile bu alanda en yüksek sayıda araştırmayla karşımıza çıkmıştır. Sorumlu yazarların ülkeleri sıralamasında 189 yazar ile birinci sırada yer alan ülke ABD olarak belirlenmiştir. Öne çıkan konular ve bunların zaman içindeki dağılımları, köpeklerin bu alandaki en çok çalışılan hayvan türü olduğunu göstermiştir. Hiperkoagülabilité ve immün ilişkili hemolitik anemi konusunda çok sayıda çalışma saptanmasına rağmen, son 3 yılda antitrombotikler ve rasyonel kullanım gibi yeni konular da dahil edildiği tespit edilmiştir. Yapılan bibliyometrik analiz, bu alanda zaman içerisindeki değişiklikleri ve konunun güncelliğini göstermiştir. Bu çalışma, TEG'nin veteriner klinik kullanımına dair araştırmalarının gelişim ve değişiminin ve bu konuyla ilgili gelecekteki araştırmaları yönlendirmeye yardımcı olacak kapsamlı bir bibliyometrik analizini göstermektedir.

Anahtar Kelimeler: Bibliyometri, Klinik, Tromboelastografi, Veteriner.

Introduction

Thromboelastography (TEG) is a method developed in 1948 by Helmut Hartet (Hartet, 1948). Some modifications of the method occurred over years and its first use in animal experiments began in the 1960s (Wiinberg and Kristensen, 2010). It is reported that TEG analysis is superior to standard coagulation tests performed with plasma as it is performed with whole blood and thus includes all components that contribute to coagulation in the blood (Wiinberg and Kristensen, 2010). Based on the same technique two different machines are available TEG (Heamometrics, USA) and rotational thromboelastometry (ROTEM, Pentapharm GmbH, Germany). The ability of TEG to detect hypo- and hypercoagulable states has led to its use in clinical studies. Species-specific validation for the assessment of coagulation abnormalities with the TEG in experimental studies in human disease modelling in laboratory animals were performed in rats by Cam et al. (2015), Cruz et al. (2017), in mice by Kaur et al. (2019), Schroeder et al. (2021), in pigs by Strandberg et al. (2016), in rabbits by Studer et al. (2021) and in ovine by Johnson et al. (2018). In addition to these studies, interest in the clinical use of TEG in animals has increased over time (Wiinberg and Kristensen, 2010). Many TEG and/or ROTEM reference value studies have been published in horses by Honore et al. (2021), Scruggs et al. (2016), in cattle by Sommerey et al. (2014), in calves by Borreli et al. (2017), in dogs by Bauer et al. (2009), Pereira et al. (2020), in cats by Alwood et al. (2014), Doderlein and Mischke, (2015), Engelen et al. (2017) and pet rabbits by Bassan et al. (2023). Different clinical studies in dogs for the establishment of coagulation abnormalities via TEG were reported in immune-mediated hemolytic anemia by Fenty et al., (2011), Goggs et al. (2012), Sinnot et al. (2009), in different cancer types by Kristensen et al. (2008), in chronic enteropathy by Dixon et al. (2021), in dilated cardiomyopathy by Yilmaz et al. (2017), in monitoring transfusion by Langhorn et al. (2019), in hyperadrenocorticism by Kol et al. (2013), in critical illness by Han et al. (2022), Majoy et al. (2015) and assessment of DIC by Wiinberg et al. (2008). TEG evaluations in obese horses were studied by Lovett et al. (2022) and horses with gastrointestinal diseases by Mendez-Angulo et al. (2010). Coagulation abnormalities in cats with cholestatic liver disease were reported by Kakar et al. (2021) and factor-XII deficiency by Blois et al. (2015). A study in cats with hypertrophic cardiomyopathy and TEG evaluation of hemostatic status is still in progress (Wilkinson and Menciotti, Virginia Maryland, College of Veterinary Medicine, USA). At the same time, due to the cost of TEG analyzes, some clinical studies have sought an alternative assessment of coagulation by comparing TEG results with conventional coagulation tests (Corda et al., 2023; Rubanick et al., 2017). When the mentioned studies are assessed, it appears that TEG studies will remain popular due to the complexity of the coagulation mechanism and its interaction with diseases.

Bibliometric analysis is a statistical method that helps to reveal the relationship and impact mechanisms of the sociometric and networks of a scientific study (Kaplan and

Altay, 2023; Önder and Tirink, 2022). Thanks to this method, the bibliographies of scientific studies are evaluated, and detailed information is provided about the past and present situation, its changes over time, scientists and institutes working in the field under study, and their collaboration status (Ergin et al., 2023a). Bibliometric analysis is a statistical method that can be performed before carrying out a scientific study in the relevant field, allowing researchers to avoid wastage by providing researchers with features that need to be examined, time, labor and up-to-date information (Altay and Kaplan, 2023).

In this context, the bibliometric analysis of veterinary clinical use of TEG aims to determine how this field of study has developed over time and to determine which areas within this field are open to research and will be beneficial. The results of this analysis will identify researchers, institutions and countries with which collaboration would be appropriate. In this way the present study could be a resource, summarizing information for planning a TEG study in clinical veterinary medicine.

Material and Methods

This study enrolled 371 documents between the years 1998 – 2023 (September) which were indexed in the Web of Science (WoS) database. The determination of studies specifically reported for veterinary clinical use and not for human medicine models in laboratory animals, for this, keywords and journals were carefully chosen.

For the statistical analysis the data set from the Web of Science (WoS) database was downloaded in a format suitable for statistical analysis, using the keywords "thromboelastography" and "veterinary" and year ranges (1980-2023). The prepared data set was edited with the help of the R software "bibliometrix" package and data analysis was performed (Aria and Cuccurullo, 2017). Tables and graphs were organized in a meaningful way to better understand the bibliometric features and were interpreted (Ergin et al., 2023b). Bibliometric analysis was materialized by the bibliometric properties of 371 documents. Ethics committee approval was not required for the present study.

Results

The results of primary data showed that the majority of 371 documents were 321 articles (plus 4 early access articles and 7 proceeding papers), followed by 23 meeting abstracts, 3 editorial materials, 1 letter, 1 correction and 1 early access correction.

Annual scientific production results show that the highest number of articles, 39 articles, were published in 2012 and the number of articles first increased above 10 in 2008. After 2012, according to the WoS database, the number of articles published in this field did not exceed 30. Whereas the average citations per year results showed that articles from the year 2000 got a maximum mean total

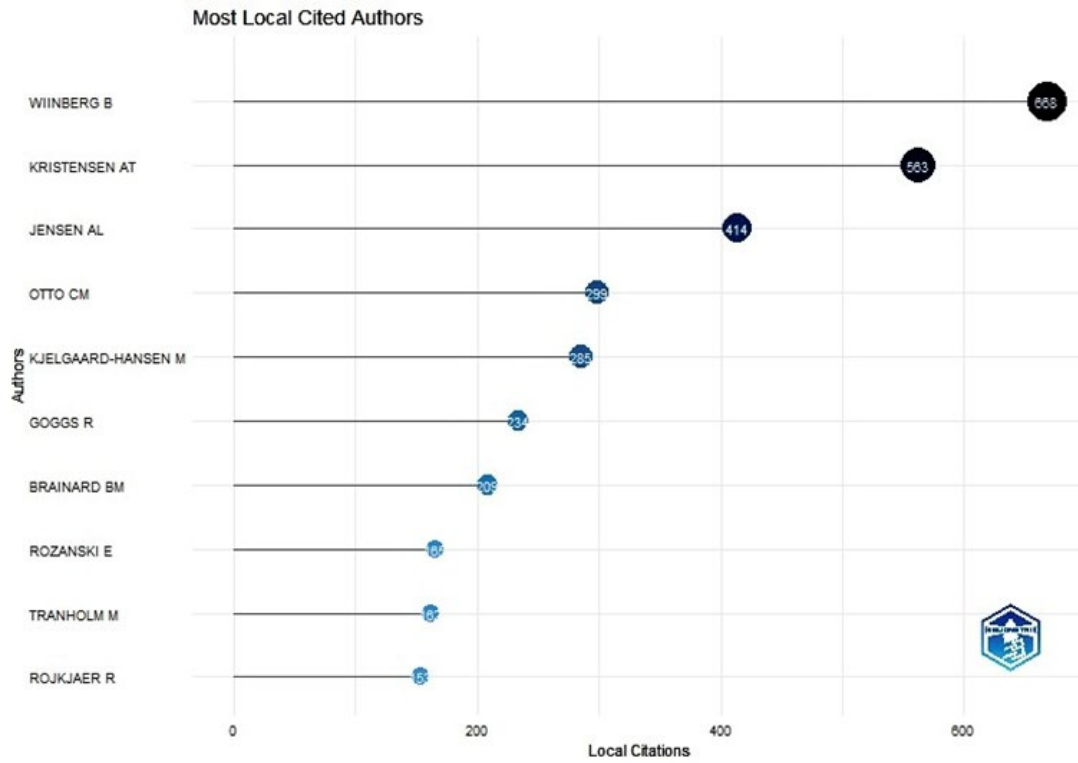


Figure 1. Most Local Cited Authors.

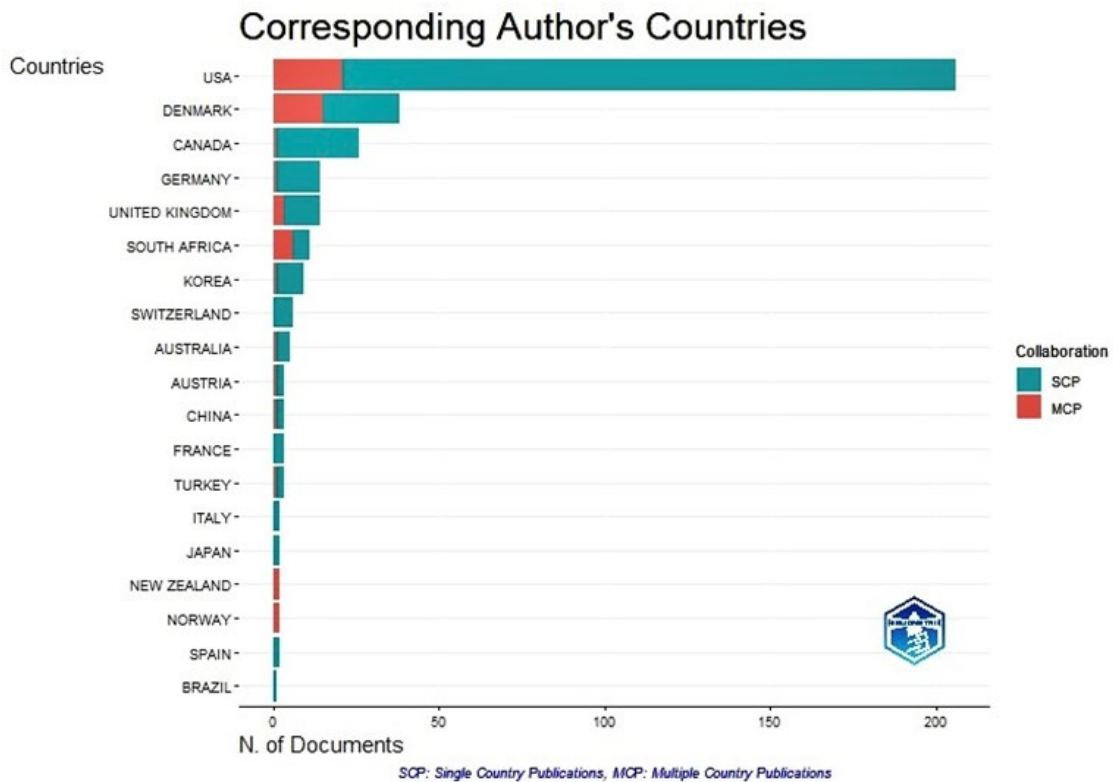


Figure 2. Corresponding Author's Countries.

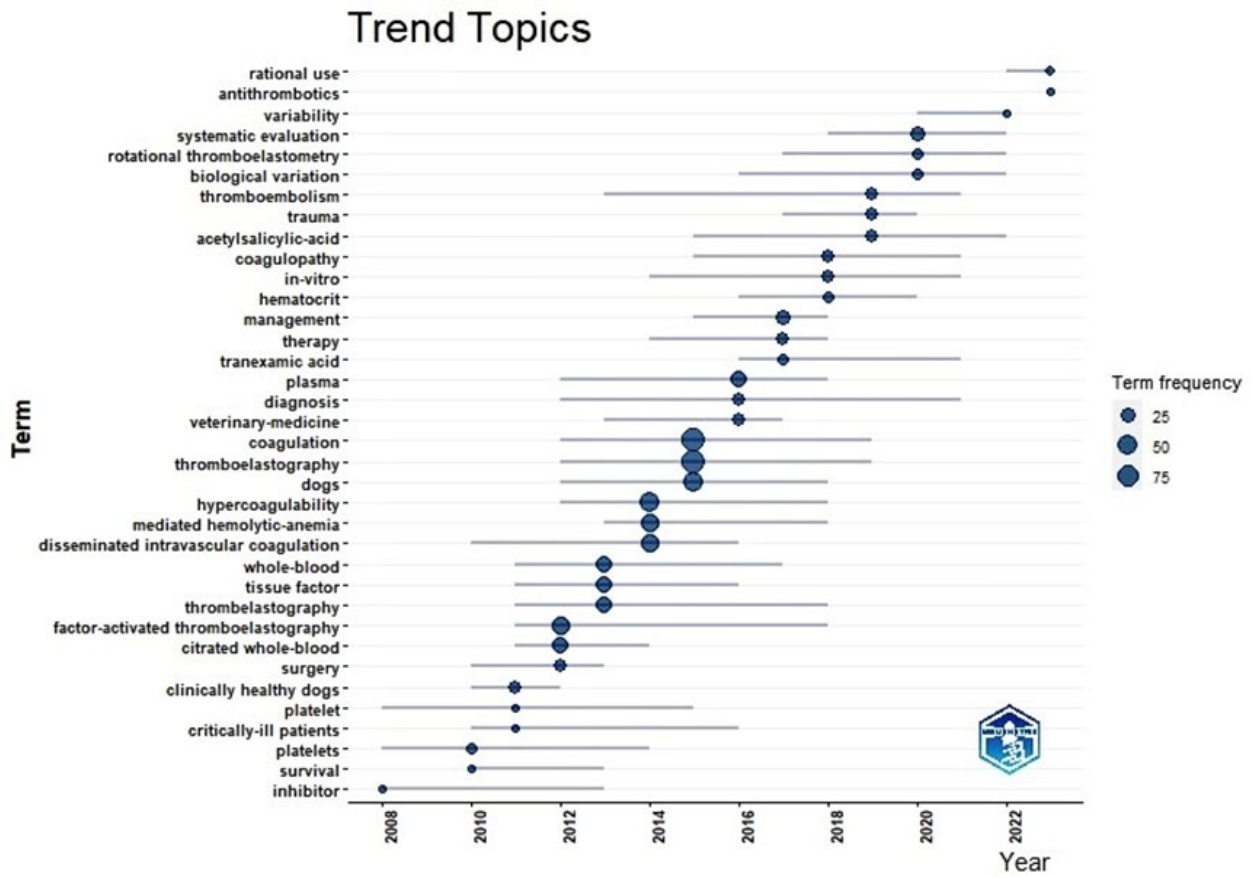


Figure 3. Mostly used keywords and their timespan.

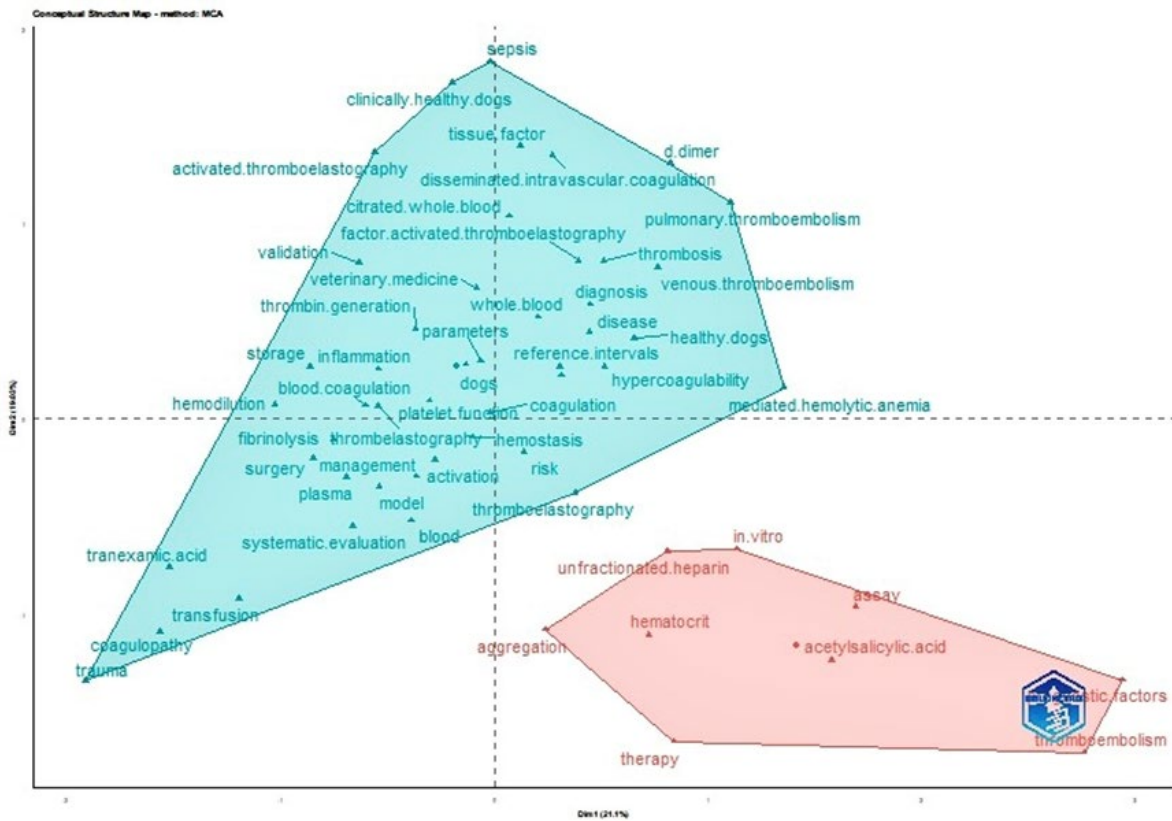


Figure 4. Conceptual structure map

ten have the highest frequency of occurrence in the years 2013-2015 and later. Besides the keyword antithrombotics, in the last 3 years, the term rational use and variability were included in studies.

The factorial analysis, worked out by the multiple correspondence analysis (MCA) method, of study concepts based on keywords, resulted in two clusters (Figure 4). The clusters had shown that TEG's veterinary clinical use studies were examined in two different concepts. The bigger blue cluster 1 demonstrated keywords, which were generally used together in articles and the distance between the words determines the frequency of the use together. The closer the words are, the more often they are used together and the further apart they are, the frequency of use together is low. It can be observed that the topics of dogs, coagulation, reference intervals, thromboelastography and hemostasis had been used together in studies. The red cluster 2 appeared with 9 words, which were including and generally about the topics therapy and assay. The word dendrogram made it easier to identify which words are close or far to each other (Figure 5). The words in blue color in the word dendrogram in Figure 4 reflect the words in cluster 2 from Figure 3 and the red ones are the words from cluster 1. The height of the dendrogram measures the distance between word clusters, and the distance between words on the horizontal axis determines different concepts. Words that are close to each other explain concepts that are close or similar to each other. In this case, factor activated thromboelastography and acetyl salicylic acid were not used together frequently enough to describe a study concept. Whereas it can be suggested that disease, diagnosis and hypercoagulability were topics of a study design. The change of topics in veterinary clinical use of TEG in future studies could change the factorial analysis.

The collaboration of studies based on countries had shown the USA with the highest number of collaborative scientific studies and an outstanding collaboration with Denmark. Followed by the scientific partnership between Denmark and South Africa.

Discussion and Conclusion

The low number of documents based on WoS database, despite a time span of 25 years, was remarkable. The costs of TEG evaluations mentioned by Corda et al. (2023), could have been a contributing factor to this result. The annual increase of documents in veterinary clinical use of TEG was analyzed as %11.73 regarding an increasing trend of scientific research. Only 7 single authored documents were detected, whereas 1152 authors were included in scientific documents in this field. Co authorship is notably high and could be called a need. One of the articles in 2000 titled "Evidence of hypercoagulability in dogs with parvoviral enteritis" by Otto et al. was the first publication of hypercoagulation detection via thromboelastography in clinical ill dogs. It is possible to assume that the studies published in these years contain basic and valuable information about the clinical use of thromboelastography in veterinary medicine. While the number of articles identified

in this field was 19 between 2000 and 2007, at least 10 or more studies were identified every year after 2007.

The most relevant author Kristensen A.T. with 39 articles, was ranked in second place in the contribution of published set of articles, assumably due to collaboration with more authors.

The country-based collaboration results showed a cooperation triangle between the USA, Canada and Europe (Denmark, United Kingdom and Germany). It is also detectable that the USA worked cross-continental with Australia and New Zealand. The co-authorship in this field between countries hadn't shown a strong impact on the total number of publications as seen in Figure 2. The USA got the first place with 206 articles in country-based scientific production ranking, mostly without any other country collaboration.

The first publication regarding the use of TEG in clinical veterinary medicine by Otto et al. (2000) originated from the USA, and in accordance with the present study results, it seems that studies on this subject continue to be carried out with great interest in the USA.

Despite the high difference in the number of publications and total citations on a country basis, the impact of the studies, based on average article citation numbers, of China, Denmark, UK and Germany is quite high in contrast to USA. However, these total citation numbers include global and local citations. Local citations were documents in the field of veterinary clinical use of TEG, whereas global citations involve the whole WoS database without any study field limitations. The number of citations of the top 10 most local cited publications was determined to be over 47. Four of these articles are documents with content regarding the use of TEG in veterinary medicine and especially in dogs. Six of them are related to the evaluation of coagulation by TEG in dogs depending on disease, symptoms or breed.

In fact, TEG research in the veterinary field started with the possibility of diagnosing hypercoagulation with a single analysis, and this showed itself in the keyword rankings with "hypercoagulation" on the fourth place. Here it can be determined that a study on treatment is not among the top ten topics but in the last year "antithrombotics" was used 5 times as seen in Figure 3 and it can be concluded that studies including treatment may attract interest in the future. Topics appeared in the last 5 years have shown studies on the routine use of TEG and the variability of analysis results, which might be a sign that efforts are being made to use TEG safely as a diagnostic tool in routine veterinary use.

This study showed that TEG in veterinary clinical use is a relevant research area with topics changing and making progress over time. The low number of studies in some animal species such as horses and cats show that more information is needed in this field and points to an area that is open to study. Likewise, although monitoring patients with TEG in the treatment of coagulopathy in the veterinary clinical field is very important and one of the target purposes of the analyzer, there are deficiencies in the literature. It is undeniable that future studies planned in this field will contribute significantly to the literature in order to ensure

safe clinical use on a routine basis. The information obtained as a result of bibliometric analysis could help in the design of future studies related to TEG in veterinary clinical use.

Conflict of Interest

The authors stated that they did not have any real, potential or perceived conflict of interest.

Ethical Approval

This study is not subject to HADYEK permission in accordance with Article 8 (k) of the "Regulation on Working Procedures and Principles of Animal Experiments Ethics Committees"

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Similarity Rate

I declare that the similarity rate of the article is 4% as stated in the report uploaded to the system.

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