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# Ultrasonographic findings of abdominal thrombosis in dogs

[*Vascular ultrasonographic findings of abdominal thrombosis in dogs*]

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## ABSTRACT

This retrospective case series study describes the clinical and vascular ultrasound findings of 26 dogs diagnosed with abdominal thrombosis. Images were selected based on the detection of intravascular echogenic thrombus or the absence of vascular flow on color Doppler, confirmed by surgery or necropsy. Images were acquired using the Mylab 40 model, with linear and microconvex multifrequency probes. All the reports were evaluated along with the corresponding images by a veterinary diagnostic imaging radiologist. The ultrasonographic aspects evaluated were echogenicity (92.3%), anechogenicity (7.7%), vascularization (11.5%), mineralization (15.4%), and recanalization (7.7%) of the thrombosis. The vascular and hemodynamic findings were dilation of the affected vein (57.7%), total occlusion of blood flow (30.8%), presence of turbulent flow (65.38%), and visualization of smoke signal (blood flow detected as moving echogenic points in dynamic bidimensional mode) (11.5%). Neoplasms (19 cases) and nephropathies (13 cases) were the most common clinical conditions in the affected dogs. Eleven cases of vascular invasion due to adrenal neoplasms were identified. The results indicate that the vascular ultrasound examination is an important method for diagnosis, as 23 of the 26 cases did not show any clinical signs of thrombosis.

Keywords: canine, diagnostic imaging, thrombus

## RESUMO

*Este estudo de série de casos retrospectivos descreve os achados clínicos e ultrassonográficos vasculares de 26 cães diagnosticados com trombose. As imagens foram selecionadas baseadas na detecção de trombo ecogênico intravascular ou na ausência de fluxo vascular ao Doppler colorido, confirmado por cirurgia ou necropsia. O equipamento utilizado na aquisição das imagens foi o modelo Mylab 40, com probes multifrequenciais linear e microconvexa. Todos os relatórios foram avaliados com as imagens correspondentes por um veterinário radiologista. As características ultrassonográficas avaliadas foram: ecogenicidade (92,3%), anecogenicidade (7,7%), vascularização (11,5%), mineralização (15,4%) e recanalização (7,7%) das tromboses. Os achados vasculares e hemodinâmicos observados foram: dilatação da veia afetada (57,7%), oclusão total do fluxo sanguíneo (30,8%), presença de fluxo turbulento (65,38%) e visibilização do sinal de fumaça (fluxo vascular visível como pontos ecogênicos em modo bidimensional dinâmico) (11,5%). As neoplasias (19 casos) e as nefropatias (13 casos) foram as condições clínicas mais comuns nos cães afetados. Foram identificados 11 casos de invasão vascular decorrentes de neoplasia de adrenais. Os resultados indicaram que o exame ultrassonográfico vascular é um método importante para diagnóstico, considerando-se que, em 23 casos, não ocorreram sinais clínicos determinantes de trombose.*

*Palavras-chave: caninos, diagnóstico por imagem, trombo*

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## INTRODUCTION

Thrombosis is an intravascular pathological aggregation of blood components, mainly platelets and fibrin, which adhere to the vascular bed and alter or obstruct the blood flow (Lamb *et al.,* 1996). A wide variety of diseases are involved in the processes of thrombi or emboli formation (Nelson and Couto, 2014; Boswood *et al.,* 2000). The clinical signs are associated with the dimensions, location and the number of thrombi, the degree and duration of the obstruction, the type of thrombus (neoplastic or otherwise), the compensatory mechanisms, and the primary disease (Konečný, 2010; Stone *et al.,* 2017). Nevertheless, due to the rapid physiological degradation of the thrombus and the collateral neovascularization, most processes do not result in clinical signs (Nelson and Couto, 2014).

Given its multifactorial aspect and diverse manifestation, the clinical diagnosis of thrombosis is challenging and underestimated in the veterinary medicine (Konečný, 2010). A comprehensive and detailed anamnesis and physical examination contribute to the identification of the main factors related to thrombosis, thus helping to establish the possible causes of the condition (Nelson and Couto, 2014).

Imaging diagnosis is often used in cases of suspected thrombosis (Stone *et al.,* 2017). Its noninvasive nature and easy accessibility make vascular ultrasound the first choice of examination (Karande *et al.,* 2016). This technique allows for real-time analysis of the vascular mapping, using the two-dimensional mode (B-mode) ultrasound simultaneously with color Doppler, in addition to allowing the evaluation of the morphological and hemodynamic characteristics of the main abdominal blood vessels, as well as of those of adjacent tissues (Solano *et al.,* 2010; Karande *et al.,* 2016). Therefore, it is possible to detect thrombi in several blood vessels, such as the vessels of the portal system, caudal vena cava, abdominal aorta, and iliac vessels (D'anjou and Carmel, 2015).

The aim of the present study was to describe and characterize the vascular ultrasound findings related to abdominal thrombosis in dogs.

## MATERIALS AND METHODS

The study was conducted based on a retrospective series of cases of thrombosis in dogs, obtained over a period of 43 months (from June 2016 to December 2019). The data was collected from the archives of the sector of Diagnostic Imaging at the Veterinary Hospital of the Universidade Federal de Minas Gerais. Images were acquired using the Esaote Maylab 40 model, with linear (7.5MHz -12MHz) and microconvex (5Mhz-8MHz) multifrequency probes. For the vascular ultrasound imaging, a two-dimensional scan was established to initially identify the large abdominal blood vessels, such as the aorta and the caudal vena cava. Then, the vascularization was assessed in the hilum region of the main organs of the abdomen, including the renal arteries and veins, portal vein, phrenic-abdominal vein, and splenic or lienal veins. Color Doppler Mode was subsequently used for hemodynamic mapping.

The cases with the best ultrasound images and diagnosis of abdominal thrombosis were selected based on the detection of intravascular echogenic thrombus or the absence of vascular blood flow, as visualized by color Doppler and confirmed by surgery or necropsy in case of death. Cases of vascular alterations caused by neoplastic compressions without the identification of vascular invasion by ultrasound examination were excluded.

Twenty-six cases were selected. All the reports were evaluated along with the corresponding images by a veterinary diagnostic imaging radiologist. The ultrasound characteristics evaluated in the vessels affected by thrombus were: echogenicity, anecogenicity (thrombus not visible in two-dimensional mode), vascularization (blood vessels stained inside the thrombus on color Doppler), mineralization (posterior acoustic shadow collector), recanalization of thrombosis (tubular blood flow adjacent to the thrombus), dilation of the affected vein, total occlusion or turbulence of blood flow (color mosaic on color Doppler), and smoke signal visualization (vascular flow visible as echogenic dots in motion on dynamic two-dimensional examination).

The clinical and epidemiological traits diagnosed by imaging exams or laboratory tests and

ultrasonographic findings of the thrombotic processes are described in this study.

## RESULTS AND DISCUSSION

Of the 26 cases evaluated, 19 were females (73.07%) and seven were males (26.92%). The patients were between four and 16 years old. Of these, 25 (96.15 %) were eight years old or older. The breeds included four Schnauzers, two Poodles, three Dachshunds, two Rottweilers, two Labrador Retrievers, two Akitas, one Pit Bull, one Golden Retriever, one Basset Hound, one Lhasa Apso, one Brazilian Terrier, and six mixed-breed dogs. Their weights varied from 6.5kg to 48kg.

Only three (11.53%) patients underwent ultrasound examination due to a previous suspicion of thrombosis. All patients presented associated comorbidities, of which the most frequent were the neoplastic processes and nephropathies diagnosed by abdominal ultrasound or laboratory tests. Nineteen patients (73.07%) were diagnosed with abdominal neoplastic processes by ultrasonography, and 13 were diagnosed with kidney problems, with the respective biochemical tests showing an increase of serum urea and creatinine. Other diagnosed conditions were: pyometra, hepatopathy, diabetes *mellitus*, splenic torsion, enteritis, hyperadrenocorticism, traumatism, peritonitis, and anemia.

Of the total number of thrombi observed in the ultrasound examinations, 19 were venous (73.08%) and seven were arterial (26.92%). Among the venous, 11 (57.90%) were in the caudal vena cava and eight (42.10%) were observed in the splenic vein. All the seven arterial cases occurred in the abdominal aorta, three of which extended to the iliac arteries.

Ten of the thrombi located in the caudal vena cava and one in the abdominal aorta originated from adrenal glands that showed ultrasound characteristics indicative of malignant neoplasms, such as increased dimension, heterogeneous aspect, vascular invasion (Fig. 1A), and thrombotic vascularization (Fig. 1B).

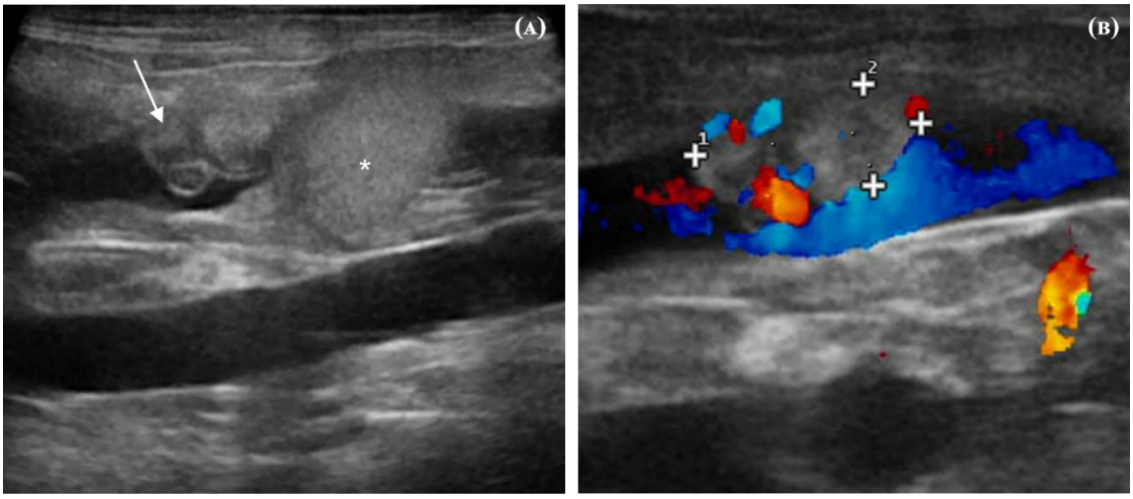


Figure 1. Longitudinal vascular ultrasound images of a dog, female, 13 years old, 8kg, with neoplasia in the right adrenal gland: (A) B-mode image showing the tumor thrombus in the caudal vena cava (arrow) continuous to the neoplastic adrenal gland (*). (B) Color Doppler image showing the blood vessels inside the tumor thrombus (cursors).

The large number of cases found by vascular ultrasound that lacked any specific clinical signs of thrombosis emphasizes the difficulty of the clinical diagnosis (Konečný, 2010) and the importance of the imaging exams (Stone *et al.*, 2017).

The ultrasonographic aspects evaluated were echogenicity, anechogenicity, vascularization, mineralization (artifact of posterior acoustic shadowing), and recanalization (blood flow inside the echogenic thrombus by color Doppler). The vascular and hemodynamic findings were dilation of the affected vein, total

occlusion of blood flow, presence of turbulent flow (visualized by color Doppler), and visualization of smoke signal (blood flow detected as moving echogenic points by dynamic B mode).

The ultrasonographic findings related to the thrombotic process were similar to those described in humans (Tapson *et al.*, 1999; Fang *et al.*, 2015; Karande *et al.*, 2016; Stone *et al.*, 2017) and are shown in Table 1 and Fig. 2.
The causes of thrombosis identified in this report agree with the potential causes previously reported for thrombosis in small animals, such as nephropathies, neoplasms, pyometra, hepatopathy, anemia, diabetes *mellitus*, splenic torsion, enteritis, and peritonitis (Boswood *et al.*, 2000; Nelson and Couto, 2014). Nevertheless, the main comorbidities observed were the neoplastic processes and nephropathies, which are considered relevant causes of thrombosis (Nelson and Couto, 2014). This result may have been influenced by the routine of the Hospital, as it provides specialized services in Oncology and Nephrology.

Given the variety of breeds and weights of the animals, no correlation of these characteristics with thrombotic processes was observed, as reported in other studies (Van Winkle and Bruce, 1993). However, most of the dogs were eight years old or older. This was associated with the predisposition of elderly patients to conditions that potentially cause thrombosis (Nelson and Couto, 2014).

The larger number of venous cases observed was also associated with the prevalence of neoplastic processes, which are predisposing factors for venous thrombosis (Jarrett *et al.*, 2002). Moreover, ten of these cases occurred due to the invasion of the caudal vena cava by adrenal neoplasms. This invasion is considered relatively common due to pheochromocytomas, a type of rare malignant tumor that occurs in the adrenals (Louvet *et al.*, 2005). However, it was not possible to classify the types of adrenal neoplasms in the present study.

The ultrasound findings of thrombosis, such as echogenicity, dilation of the vein, mineralization, thrombotic vascularization, occlusion, turbulence, smoke signal, and recanalization, are the same observed in humans (Sigel *et al.*, 1983; Frimerman *et al.*, 1994; Tapson *et al.*, 1999; Zaremba and Nomura, 2012; Turhan *et al.*, 2013; Fang *et al.*, 2015; Rohatgi *et al.*, 2015; Karande *et al.*, 2016). Few studies assessing the ultrasonographic characteristics of thrombi have been reported in veterinary medicine (Lamb *et al.*, 1996; Finn-Bodner and Hudson 1998), and these have few illustrations and lack the detailed characterization of all the findings described here to be searched for a thrombus.

Table 1. Absolute number and percentage of the vascular ultrasound findings of 26 dogs diagnosed with abdominal thrombosis

| | | |
|---|---|---|
| Thrombus echogenicity | Anechogenic | Echogenic |
| | 2(7.7%) | 24(92.3%) |
| Vascularized thrombus | Absence | Presence |
| | 23(88.5%) | 3(11.5%) |
| Mineralized thrombus | Absence | Presence |
| | 22(84.6%) | 4(15.4%) |
| Recanalized thrombus | Absence | Presence |
| | 24(92.3%) | 2(7.7%) |
| Vein dilation | Absence | Presence |
| | 11(42.3%) | 15(57.7%) |
| Vascular occlusion | Partial | Total |
| | 18(69.2%) | 8(30.8%) |
| Turbulent flow[a] | Absence | Presence |
| | 8(30.8%) | 17(65.38%) |
| Smoke signal | Absence | Presence |
| | 23(88.5%) | 3(11.5%) |
| Collateral Vascularization | Absence | Presence |
| | 23(88.5%) | 3(11.5%) |

[a] In one patient, Color Doppler analysis was not performed during the examination.

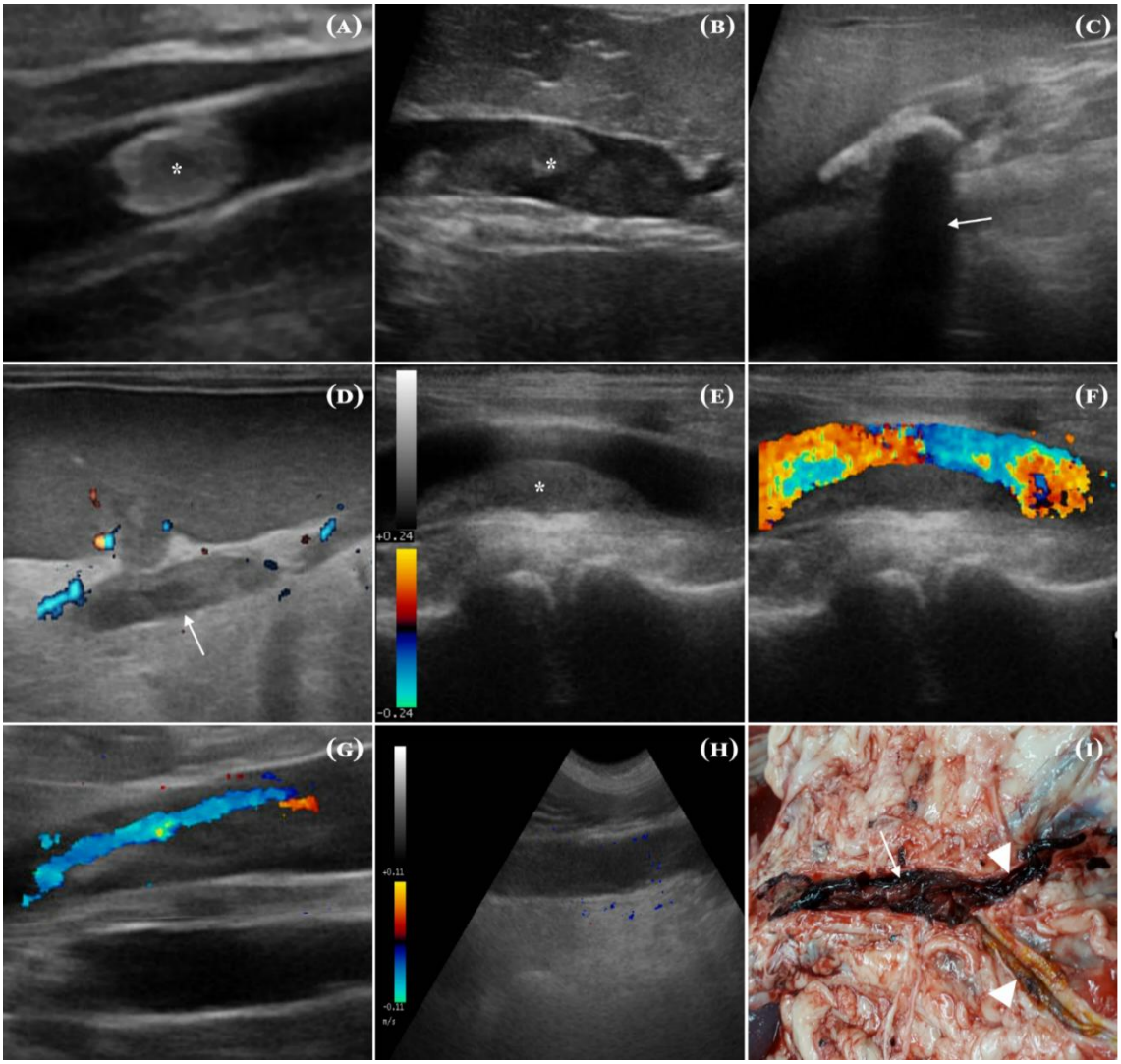


Figure 2. Ultrasound findings of abdominal thrombosis in dogs: (A) Echogenic thrombus (*) in the lumen of the aorta. (B) Dilated splenic vein with echogenic thrombus (*). (C) Mineralized thrombus forming an artifact of posterior acoustic shadowing (arrow) in the lumen of the caudal vena cava. (D) Absence of blood flow in a splenic vein, due to occlusion caused by the thrombus (arrow), as visualized by power Doppler. (E) and (F) Duplex image showing echogenic thrombus (*) adhered to the intima of the aorta and turbulent flow by color Doppler (mosaic signal). (G) Blood flow adjacent to the echogenic thrombus by color Doppler, indicative of recanalization. (H) Absence of blood flow by color Doppler in the abdominal aorta due to anechogenic thrombus. (I) Macroscopic image of the necropsy of the patient in 2H, showing thrombi in the aorta (arrow) and abdominal iliac (arrowheads) arteries.

A remarkable number of echogenic thrombi (92.30 %) were observed using the B-mode in the lumen of the affected vessels. However, in the two cases, the thrombi were anechogenic and required the use of Doppler for diagnosis, which was defined by the absence of blood flow (Zaremba and Nomura, 2012). Determining the absence of blood flow in an abdominal vessel requires experience of the operator and knowledge of the technical settings appropriate for Doppler. Otherwise, it may lead to a false positive diagnosis (Finn-Bodner & Hudson 1998). The low number of anechogenic thrombi may be attributed to the difficulty in detecting hemodynamic alterations and the absence of clinical suspicion to guide the investigation.

The identification of ultrasound alterations associated with recent thrombotic events, such as dilation of the affected vein (Tapson *et al.*, 1999; Fang *et al.*, 2015; Karande *et al.*, 2016; Stone *et al.*, 2017), or chronic thrombosis, such as mineralization (Van Winkle and Bruce, 1993), is important to help determine the treatment and prognosis of the patient (Fang *et al.*, 2015; Stone *et al.*, 2017).

## CONCLUSION

The ultrasonographic findings revealed and characterized in this study represent a useful tool for a complete and detailed evaluation when faced with a condition caused by thrombosis. The correct identification of ultrasound changes caused by thrombi is essential for diagnostic accuracy and for assertive therapeutic decision-making, especially in the absence of clinical signs in many cases. Special attention should be given to ultrasonographic investigation to search for thrombi in oncological and nephropathic patients.

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